FARM DECISION AND RESOURCE PRODUCTIVITY RELATIONS, WHEAT AND SORGHUMS, CENTRAL AND WESTERN KANSAS, 1917-53

by

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INTRODUCTION

The forces behind the supply of farm products have not been studied extensively or very successively. This lack of research product is not explained by a lack of value to such insights. The primary object of this study was to determine the interrelation between a number of physical, agronomic, and economic variables which determine the annual production of winter wheat and grain sorghum in the western two-thirds of Kansas. Specifically, an attempt is made to approximate supply response functions for wheat and grain sorghums in Kansas and to estimate the parameters of a number of alternative formulations of the functional relationships involved.

Increased understanding of supply relations will make predictions on effects of government policies (that have resulted from the readily apparent surpluses) more accurate, but the use of the findings will not be entirely restricted to this use. Analysis is not only made of the commitment of resources but of their consequent productivity after commitment. These functional relations will yield efficiency measures, which in turn can be useful for such further studies as resource valuation, profitability of farm practices, and farmers' use of appropriate strategies in allocating resources under specified conditions. This study thus goes beyond derivation of supply functions, where supply refers to a schedule for some unit of time, of all the possible quantities offered by sellers in correspondence with a list of possible prices. Farmers in this area respond, but the response is in terms of resources committed to various uses. In this study the production of resource bundles is also studied, given the commitment.

This study was restricted to small geographical areas. This was done to insure a maximum of homogeneity within areas. The smallest area, and if properly sampled, the most homogeneous area, would be a cross section of farmers. An increased number of variables could be taken into account, and commitment of resources and productivity of resources could be studied. It was not possible to obtain data from this source. Consequently, county data were used. The data were available and were believed adequate for the analysis planned. Although data obtained experimentally were available and adequate for the productivity study, it was not possible to study resource commitment. To study both phases of the problem it was necessary to use the county data.

The use of data from smaller areas differentiates this study from most supply studies that have been conducted. Most of the previous studies have covered broad geographical areas, with results difficult to interpret. Within the large areas, measures of response encompassed farmers with a difference in the degree to which assets were held fixed, or, the same thing, differences in the length of run. Likewise, the profitableness of alternatives differed from farm to farm and from area to area. It is not claimed that these are not problems in this study. However, it is believed that the farms within areas are as homogeneous as can be obtained without a sample of farms.

This study is a time series analysis, and in general covers the period 1917-53. As a whole there were no changes that would affect the structure of the equations used. The period was closed at 1953 because government programs were believed to have affected farmers' decisions beyond that date. There were programs before 1953, but it was not believed that they were of sufficient influence to merit further change in the period selected for study.

This study is an introductory study, with data from only two counties analyzed. Similar data to that used for these counties has been punched on

IBM cards for other counties. These include 66 counties in Central and Western Kansas. A broader study will be made in the future, where benefits have been gained from this more limited experience.

Procedure

Single equation multiple regression analysis was the method used for this study. For each equation, it was possible to determine one dependent variable (endogenous) that was a function of independent variables, including both exogenous and lagged endogenous variables that could be regarded as predetermined. Therefore, simultaneous equation methods not only are unnecessary, but

> If an equation contains one current endogenous variable and several predetermined variables and if the current endogenoue is regarded as dependent in applying least squares, then the least-squares and limited information procedures are identical, as are the assumptions under which they are derived (Hildreth and Jarrett, 1, pp. 70-71).

Under these conditions, least-squares procedures yield unbiased estimates of parameters.

Problem

Farmers in Central and Western Kansas must make decisions concerning the acreage of crops that they seed and the techniques of production that they use. The major decisions that they make, and the interrelation of these decisions is shown in Table 1. The making of a particular decision will influence the decisions that are made later. The making of a decision leaves open the possibility that certain sequences of decisions may be made later and at the same time precludes the possibility that other decisions may be made later.

Table 1. Farm decision calendar, for crops, Central and Western Kansas.

Summer 1949	Fall 1949	Spring 1950		Summer 1950	
(1) Wheat crop harvested	seeded to wheat	wheat abandoned	seeded to sorghum	sorghum	(3)
			seeded to other crops	crops other than wheat or sorghum	(4)
			not seeded (fallow)	fallow	
		wheat not abandoned		(continuous) wheat crop harvested	(1)
	not seeded to wheat		seeded to sorghum	sorghum	(3)
			seeded to other crops	crops other than wheat or sorghum	(4)
			not seeded (fallow)	fallow	(2)
(2) Fallow	seeded to wheat	wheat abandoned	seeded to sorghum	sorghum	(3)
			seeded to other crops	crops other than wheat or sorghum	(4)
			not seeded (fallow)	fallow	(2)
		wheat not abandoned		wheat (after fallow) crop harvested	(1)
	not seeded to wheat		seeded to sorghum	sorghum	(3)
			seeded to other crops	crops other than wheat or sorghum	(4)
			not seeded (fallow)	fallow	(2)
(3) In sorghum	harvested crop of sorghum		seeded sorghum	sorghum	(3)
			seeded to other crops	crops other than wheat or sorghum	(4)
			not seeded (fallow)	fallow	(2)

Table 1. (concl.)

Summer 1949	Fall 1949	Spring 1950		Summer 1950	
		wheat abandoned	seeded to sorghum	sorghum	(3)
			seeded to other crops	crops other than wheat or sorghum	(4)
			not seeded (fallow)	fallow	(2)
	seeded to wheat	wheat not abandoned		(continuous) wheat crop harvested	(1)
(4) Crops other than wheat or sorghum	not seeded to wheat		seeded to sorghum	sorghum	(3)
			seeded to other crops	crops other than wheat or sorghum	(4)
			not seeded (fallow)	fallow	(2)

In the calendar, Table 1, any date may serve as a starting point. It is convenient, though not necessary, to start in the summer. (Years 1949 and 1950 are used as example years.) In the summer of 1949, the land will fall into one of four possible classifications; these are land on which a wheat crop was harvested that summer, land in fallow, land in sorghums, and land that is in crops other than wheat or sorghum.

The land on which a wheat crop was harvested could either be seeded to wheat or not seeded to wheat that fall. The recommended seeding date for wheat is late September or early October for this area. A sequence of possible decisions follows if the land were seeded to wheat. In the spring of 1950, the wheat could either be abandoned or left for a crop. If left for a crop, it would be harvested during the summer of 1950 on approximately July 1. If the wheat were abandoned, the land could be seeded either to sorghum or to other crops, or it could be fallowed. If the land were fallowed, it would be potential wheat seeding land in the fall of 1950. Recommended seeding dates are May 25-June 20 for sorghums, May 1 to late May for corn, and March 1-15 for oats. If the land were seeded to sorghum or corn, the growing crop would occupy the land in the summer and fall of 1950 and the land would ordinarily not be sufficiently prepared and would be too dry for wheat seeding.

Land in fallow, summer of 1949, could likewise be seeded to wheat or not seeded to wheat in the fall of 1949. The same possible decisions would follow as from land on which a crop of wheat was harvested in the summer of 1949. The one difference is that a crop of wheat after fallow could be harvested from wheat seeded on fallow land.

In the summer of 1949, some of the land will be in sorghum. This crop will be harvested in the fall of 1949 and the land will not be available for wheat. No decisions regarding the use of this land will need be made until spring, when it must be decided whether the land should be seeded to sorghum, seeded to other crops, or fallowed.

The decision in the fall of 1949, for land in a crop other than wheat or sorghum in the summer of 1949, will depend upon the crop on the land in the summer. If the crop is corn, the land will not be available for wheat seeding. If the crop was a spring sown small grain, as oats or barley, or if it were rye, the land could be seeded to wheat that fall. The same series of decisions beyond the decision to seed wheat are mapped for this land as for land on which a wheat crop was harvested in the summer of 1949. Likewise, a crop of wheat seeded on this land and harvested in 1950 would be regarded as a continuous wheat crop.

Land that can be seeded to wheat will not have a growing sorghum or corn crop on it that summer. Wheat can be seeded on land that produced wheat the previous year, spring sown small grain or rye the previous year, or that was fallowed the summer prior to seeding wheat. Sorghum can be planted on land that produced a row crop the previous year, on land seeded to wheat but abandoned, on land that produced a spring sown small grain the year before, and on land that was fallowed the summer before.

The types of land use that might be found in the summer of 1950 are the same possibilities as listed for the summer of 1949. This completes the decision cycle and the same types of decisions would be studied in the fall of 1950 and later dates as for the years illustrated.

Hypotheses stating the factors influencing the use to which land is committed at each decision-making point logically follow. It is known that soil moisture is crucial for crop production in this area, and that farmers are committing not land, as an aggregate measured in acres, but land and soil moisture. Although farmers have no control over the amount of precipitation that falls (unless they move to a higher precipitation area), they can, to some extent, control the amount of soil moisture by rotation and tillage practices, and they must, if they are to maximize profits, exercise strategy in the use of this moisture.

Scope of Study

This study covered two counties in Kansas, Barton and Finney, for the years 1917 to 1953. Since this is primarily a supply study of wheat, Barton County was selected because it is one of the main wheat producing counties in the state. The average production of wheat in Barton County, as shown in Table 2, for the years studied was 3,695,000 bushels. Another reason Barton County was selected over several of the other leading wheat producing counties was that the precipitation reporting station was more centrally located. Geographically, Barton County is located in the central part of Kansas, and the secondary crops are sorghums and corn.

The mean acreage of wheat seeded in Barton County for the years studied was 312,300 acres. The average acreage of wheat seeded on fallowed land was 23,400 acres, and the average acreage of continuous wheat was 288,900 acres. For Barton County, only 7.5 percent of the wheat seeded was seeded on fallowed land. Previous studies (Knight, 18) have indicated that summer fallow is profitable, at the most, once every four years for wheat. This, then, is an area in which a large acreage of land cannot be profitably fallowed. The largest acreage seeded to wheat was in 1938, with 354,000 acres and the smallest in 1948, when only 238,000 acres were seeded to wheat. The acreage of wheat abandoned in Barton County averaged 38,000 acres per year, with a mean

Table 2. Catalogue of variables and means used in supply response formulations, 1917-1953.

Variable	Description	Mean		Unit
		Barton	Finney	
X_2	Precipitation received for the six-month period from April 1 to October 1[1]	18.4	14.0	Inches
X_3	Price of wheat as announced the previous year or the season's average price	1.33	1.33	Dol./bu.
X_5	Precipitation received for the six-month period from October 1 to April 1	6.3	4.8	Inches
X_6	Index of yield ability of wheat[2]	93.0	93.0	Percent
X_8	Price ratio of $\frac{\text{sorghum}}{\text{wheat}}$	69.0	69.0	Percent
X_9	Precipitation received for the three-month period from July 1 to October 1	8.2	6.5	Inches
X_{10}	Precipitation received for the six-month period from January 1 to July 1	13.0	9.4	Inches
X_{11}	All sorghum harvested 1931-1953	24,500	66,600	Acres
X_{12}	Land available for wheat	294,000	139,600	Acres
X_{13}	All sorghum harvested	22,000	61,000	Acres
X_{14}	Wheat seeded after fallow	7.5	29.3	Percent
X_{15}	Time	35	35	Years
X_{18}	Crop acreage harvested	347,000	215,800	Acres
Y_1	Land seeded to wheat	312,300	194,300	Acres
Y_2	Wheat harvested	247,300	128,600	Acres
Y_3	Wheat yield per harvested acre	13.3	11.9	Bushels
Y_4	Grain sorghum harvested	9,000	37,000	Acres
Y_5	Sorghum yield per harvested acre	17.5	16.7	Bushels

Table 2. (concl.)

Variable	Description	Mean: Barton	Mean: Finney	Unit
Y_6	Land in fallow[3]	23,400	57,100	Acres
Y_7	Wheat abandoned	38,000	65,600	Acres
Y_8	Wheat production	3,695,600	1,654,900	Bushels
Y_9	Continuous wheat	288,900	137,200	Acres

[1] The precipitation measurements were calculated from records obtained from weather stations in each county. The station for Barton County was located at Great Bend, and the station for Finney County was located at Garden City.

[2] The index of yield ability was obtained by weighting yields of different varieties as determined by experiments at Manhattan by the percentage of Kansas wheat acreage seeded to these varieties for the different years, data supplied by the Federal-State Statistician, Topeka, Kansas.

[3] Unpublished data, Department of Economics and Sociology, Kansas State College. Original data are from Federal-State Statistician, Topeka, Kansas.

of 274,300 acres harvested each year, with an average yield of 13.3 bushels per harvested acre.

The average acreage of all sorghums harvested in Barton County was 22,000 acres, of which 9,000 acres were grain sorghums. The average grain sorghum yield per harvested acre was 17.5 bushels. The largest acreage of all sorghums harvested was 38,800 acres in 1953 and the smallest acreage harvested was 9,700 acres in 1930. The largest acreage of grain sorghums harvested was 26,300 acres in 1953, while no grain sorghums were harvested in 1934 and 1936. On the basis of acreage harvested, sorghum is considerably less important than wheat in this county.

The average yearly precipitation in Barton County was 24.7 inches, with an average of 18.4 inches during the second and third quarters, and 6.3 inches during the first and fourth quarters.

The other county studied was Finney, which is located in the southwestern part of the state. Finney is also located in a cash grain producing area, and the two most important crops for that area are wheat and sorghums.

Finney County was chosen for several reasons. First, it is located in a different and drier area of the state. The average precipitation in Finney County for the years studied was 18.8 inches; 5.9 inches less than the average precipitation in Barton County. Of the 18.8 inches of precipitation received, 14.0 inches was received during the second and third quarters and 4.8 inches during the first and fourth quarters.

Secondly, more land was fallowed in Finney County. The average acreage fallowed in Finney County for the 37 years studied was 57,000 acres. Very little fallowing was done before 1932. From 1932-53, the average acreage fallowed was 95,800 and 39,300, respectively, for the two counties.

Another reason that Finney County was selected was because experimental data are available from the Garden City Branch Experiment Station located in this county. Data from the experiment station can be tested in the equations for comparison with the results from the use of county data.

The average acreage of wheat seeded in Finney County for the 37 years studied was 194,300 acres. The largest acreage seeded was 308,000 acres in 1949, and the smallest was 37,000 acres in 1918. The average acreage harvested was 128,600 acres, and abandoned acreage averaged 65,600 acres per year, or 33.7 percent per year. Under the assumption that all fallowed land, (average acreage being 57,100 acres) was seeded to wheat, the average acreage of continuous wheat was 37,200 acres, or approximately 29.3 percent of the wheat was seeded on fallowed land. Fallowing has been demonstrated to be profitable for wheat in Finney County, especially in certain years, (Knight, 18). The average yield of wheat per harvested acre was 11.9 bushels in

Finney County.

For the years studied, the average acreage of all sorghums harvested in Finney County was 61,000 acres, of which 37,800 acres were grain sorghums. The largest acreage of sorghum, 142,100 acres, was harvested in 1951, which included 113,700 acres of grain sorghums. The smallest acreage of sorghums harvested was in 1921, with only 31,200 acres. The mean yield per acre for grain sorghums harvested in Finney County was 16.7 bushels.

These two counties, then, differed on relative importance of (1) wheat, (2) sorghum, (3) fallow, and (4) average precipitation.

Summary of Equations

A summary of all equations analyzed is presented. To help clarify the timing of associated variables, the dependent variable for 1950 is shown as a function of other variables, with dates attached. For example, in the (2) acreage fallowed equation, Y_6, for 1950, is a function of X_2, 1949, Y_2, 1949, X_{11}, 1949, X_{18}, 1949, X_{15}, 1950 (date not shown, but agrees with date of dependent variable), and X_3, 1949. The year 1950 is only illustrative, but for other dates the leads and lags for the dates follow the precise pattern pictured.

(1) Wheat seeding

$Y_1 = f(X_2, X_3, X_7, X_{12}, Y_6, X_{15})$

Y_1 = seeded acreage of wheat by years, e.g., 1950 crop year shows seeded acreage in fall 1949

$X_2 = R_2 + R_3$, rainfall in 2nd and 3rd quarters of 1949

X_3 = price of wheat announced in July 1949 or 1949 season average price

X_7 = acres wheat abandoned, 1949

X_{12} = crop acreage available for wheat, fall 1949
acres harvested, 1949, wheat, oats, barley, rye, alfalfa ÷ 5

Y_6 = acreage fallowed, 1949

X_{15} = time

(2) Acreage fallowed

$Y_6 = f(X_2, Y_2, X_{11}, X_{18}, X_{15}, X_3)$

Y_6 = acreage fallowed, 1950

$X_2 = R_2 + R_3$, rainfall in 2nd and 3rd quarters of 1949

Y_2 = acres wheat harvested, 1949

X_{11} = acreage of all sorghum harvested, 1949

X_{18} = acres harvested, 1949, all crops excluding prairie hay, 4/5 of the alfalfa acreage

X_{15} = time

X_3 = price of wheat, 1949 or 1949 season average price

(3) Wheat harvesting

$Y_2 = f(X_2, X_5, X_3, Y_1)$

$Y_2 = f(X_2, X_5, X_3, Y_6, Y_9)$

Y_2 = acres of wheat harvested, 1950

$X_2 = R_2 + R_3$, 1949

$X_5 = R_4 + R_1$, 4th quarter 1949 plus 1st quarter 1950

X_3 = price of wheat, 1950

Y_1 = acres seeded, 1949

Y_6 = acres fallowed, 1949

Y_9 = acres of wheat after a crop

(4) Wheat abandonment

$Y_7 = f(X_2, X_5, X_3, Y_1)$

$Y_7 = f(X_2, X_5, X_3, Y_6, Y_9)$

Y_7 = acres abandoned, 1950

$X_2 = R_2 + R_3$, 1949

$X_5 = R_4 + R_1$, 4th quarter 1949 plus 1st quarter 1950

X_3 = price of wheat, 1950

Y_1 = acres seeded, 1949

Y_6 = acres fallowed, 1949

Y_9 = acres of wheat after a crop

(5) All sorghums harvested

$X_3 = f(X_9, X_8, X_7, X_{18}, Y_1, X_{15})$

X_3 = all sorghum acreage harvested, 1950

$X_9 = R_3$, 1950

X_8 = price ratio, $\frac{\text{sorghum 1949}}{\text{wheat 1949}}$

X_7 = acres of wheat abandoned, 1950

X_{18} = acres of all crops harvested, 1949

Y_1 = acres of wheat seeded, 1950

X_{15} = time

(6) Grain sorghums harvested

$Y_4 = f(X_9, X_8, X_7, X_{18}, Y_1, X_{15})$

Y_4 = grain sorghum acreage harvested, 1950

$X_9 = R_3$, 1950

X_8 = price ratio, $\frac{\text{sorghum 1949}}{\text{wheat 1949}}$

X_7 = acres of wheat abandoned, 1950

X_{18} = acres of all crops harvested, 1949

Y_1 = acres of wheat seeded, 1950

X_{15} = time

(7) Wheat production (linear)

$Y_8 = f(X_2, X_6, X_5, Y_9, Y_6, X_{2t-1}, X_{15})$

Y_8 = wheat production, bushels 1950

$X_2 = R_2 + R_3$, 1949

X_6 = index of yield ability, 1949

$X_5 = R_4 + R_1$, 4th quarter 1949 plus 1st quarter 1950

Y_9 = acres of continuous wheat, 1950

Y_6 = acres fallowed, 1949

$X_{2t-1} = R_2 + R_3$, 1948

X_{15} = time

(8) Wheat production (logarithmic)

$X_{8L} = f(X_{2L}, X_6, X_{5L}, Y_{9L}, Y_{6L}, X_{2Lt-1}, X_{15})$

X_{8L} = log wheat production, bushels 1950

X_{2L} = log $(R_2 + R_3$, 1949)

X_6 = index of yield ability, 1949

X_{5L} = log $(R_4 + R_1$, 4th quarter 1949 plus 1st quarter 1950)

Y_{9L} = log acres of continuous wheat, 1950

Y_{6L} = log acres fallowed, 1949

X_{2Lt-1} = log $(R_2 + R_3$, 1948)

X_{15} = time

(9) Wheat yields (linear)

$Y_3 = f(X_2, X_6, X_{14}, X_5, X_{2t-1}, X_{15})$

Y_3 = wheat yield per harvested acre, 1950

$X_2 = R_2 + R_3$, 1949

X_6 = index of yield ability, 1949

X_{14} = percentage of seeded acreage seeded after fallow

$X_5 = R_4 + R_1$, 4th quarter 1949 plus 1st quarter 1950

$X_{2t-1} = R_2 + R_3$, 1948

X_{15} = time

(10) Wheat yields (logarithmic)

$Y_{3L} = f(X_{2L}, X_6, X_{14}, X_{5L}, X_{2Lt-1}, X_{15})$

Y_{3L} = log wheat yield per harvested acre, 1950

X_{2L} = log ($R_2 + R_3$, 1949)

X_6 = index of yield ability, 1949

X_{5L} = log ($R_4 + R_1$, 4th quarter 1949 plus 1st quarter 1950)

X_{14} = percentage of seeded acreage seeded after fallow

X_{2Lt-1} = log ($R_2 + R_3$, 1948)

X_{15} = time

(11) Sorghum yields (linear)

$Y_5 = f(X_9, X_{10}, Y_6, X_2, X_{15})$

Y_5 = grain sorghum yield per harvested acre, 1950

$X_9 = R_3$, 1950

$X_{10} = R_1 + R_2$, 1950

Y_6 = acres fallowed, 1949

$X_2 = R_2 + R_3$, 1949

X_{15} = time

(12) Sorghum yields (logarithmic)

$Y_{5L} = f(X_{9L}, X_{10L}, Y_{6L}, X_{2L})$

Y_{5L} = log grain sorghum yield per harvested acre, 1950

X_{9L} = log (R_3, 1950)

X_{10L} = log ($R_1 + R_2$, 1950)

Y_{6L} = log acres fallowed, 1949

X_{2L} = log ($R_2 + R_3$, 1949)

FARM DECISION RELATIONS

As noted in the decision pattern, farmers must make commitments on the use of resources at specified times during the year. It is hypothesized that the decisions they make are related to the stocks of resources on hand at the decision-making time and to their expected discounted marginal value productivity in alternative uses. Farmers would be expected to allocate the given resources to maximize this expected return. The farmer's problem is that of using the appropriate strategy in the use of his fixed resources. This in general means that for any particular decision, the expected returns from land and moisture must cover variable costs and must be equal to or greater than opportunity costs.

Wheat Seeding

Farmers with land available for wheat seeding must decide each fall how much of this land should be seeded. This land, for the wheat acreage seeding decision, falls into three categories: land on which a crop had been harvested, or X_{12}; land on which the previous wheat crop was abandoned, or Y_7; and land that was fallowed, or Y_6. Each of these variables is assumed given for this particular decision.

The acreages X_{12}, Y_6, and Y_7 were not aggregated into one acreage total. As far as wheat seeding is concerned, each category represents a different resource. The acreage of wheat abandoned the preceding spring can go either into fallow or sorghum. The land planted to sorghum will not be available for wheat. The land (X_{12}) which was cropped to wheat, oats, barley, rye, and one-fifth of the alfalfa acreage (average length of life of alfalfa assumed five years, and 20 percent of the total stand is assumed broken up each year) is available for wheat. The soil moisture content of this soil will, in general, be low. On the other hand, the moisture content of the fallowed land will be higher.

If soil moisture readings would have been available, an aggregate measure of productive land would have been used, where measures of acres and moisture content would have both been reflected. Lacking this measure of soil moisture, land was categorized as described above.

The amount of moisture in the soil is related not only to its use but to the amount of rainfall that fell prior to seeding time. It was not known precisely what period of rainfall should be used, nor was it known whether rainfall immediately prior to seeding time should be weighted more than earlier rainfall. Although complete a priori knowledge as to how to treat this variable was not at hand, it appeared reasonable to use the total rainfall of the six-month period from April 1 to October 1. For Central and Western Kansas, most of the annual precipitation falls during these months. On land where crops were harvested the preceding summer, some of the rainfall of April, May, and early June would be used by the growing crops, and some would be lost through evaporation, but a large portion of this moisture will remain in the soil. The period was extended to October 1, the approximate planting date. The necessary land preparation operations for wheat are rather simple, and farmers in this area often wait to see how much precipitation falls in late summer before they decide to plant wheat. With possibly one or two one-way operations, the land is sufficiently prepared for seeding.

In deciding how to use this land, there are a number of things a farmer takes into account. First, he would plant only if the expected value of the crop would cover additional costs (for more land preparation, seed, drilling, combining, and hauling) that would be incurred after the decision-making time if he decides to seed wheat. This is a necessary but not a sufficient condition for justifying the decision to seed. Not only must the expected value of the specific crop cover the variable costs (costs that are variable at this stage) but this avenue of land use must promise greater expected returns than any other use. For example, either planting sorghum the next spring or fallowing the following summer for a wheat crop to be seeded a year later might show promise of more profits. If either were the case, the land would not be seeded. If neither were the case, and the expected value of the wheat crop would at least cover the variable costs (profits from the wheat crop greater than the opportunity costs), then the land would be seeded to wheat.

The decision model farmers use undoubtedly reflects the influence of crop prices, costs, and yields. It is suspected that costs are not too important a consideration at this stage, however, because variable costs are not a high proportion of total costs. It is not known exactly how cost comparisons for alternative crops are made, although it is probable that farmers assume that future costs will be at about the same level as costs at a given time. Necessary data on costs and hypotheses as to their use by farmers were not available, so this variable was not included in the equation.

The influence of yield is primarily reflected through rainfall and the amount of land in the categories as defined.

A price variable was included in the equation. There is reason to suppose that there would be some response to price, and that a high expected price for wheat would encourage farmers to seed more wheat in a given year. It would also be reasonable to suppose that the acreage response to price would be highly inelastic. The decision as to seeding would be made in the short-run, with land and moisture given, along with certain other variables not studied here, as labor, machinery, and buildings.

Some consideration was given to the use of a price relative, e.g., a ratio of wheat and grain sorghum prices. This variable was not used because it was believed that the opportunity cost of a crop of wheat seeded was the value of a crop of wheat after fallow that could be produced on the land a year later if wheat was not seeded. It is not likely that the price of sorghum is an important factor taken into account when resources are committed to wheat.

It is not known precisely what price farmers use in formulating expectations. Previous studies have used lagged prices, including weights for past prices, (Nerlove, 11). Here, the price of wheat as announced in July of that year or the season average price was used. It is believed that this is more nearly the one price farmers would expect for a crop, or a crop after fallow a year later.

Some farmers plant wheat so that they have a growing crop if precipitation falls during the spring or winter. If it does not fall, they can still harvest a poor crop of wheat, or abandon the wheat. This is a form of flexibility, and although it involves a cost (land, preparation, and seeding costs when a wheat crop is later abandoned), it may be a profitable activity because farmers have a chance of harvesting a good wheat crop some years.

Not all the factors influencing the acreage of wheat seeded could be represented explicitly in the equation. These include a wide variety of technological improvements such as muchanization, varieties, and land preparation techniques. To take into account the influence of these factors, a time variable was added to the equation. In this and other equations where the influence of time was believed to enter, it was assumed that its influence on the dependent variable was at a constant rate over time. Time has been treated this way in other studies, (Hildreth, 1, p. 65).

The basic difference in this equation and a comparable one in a previous study is in the insertion of variables to account for the influence of soil moisture. A study by Bowlen (4), p. 1178, related first differences in seeded acreage to first differences in adjusted wheat prices. He concluded that the results were "highly unsatisfactory." In an attempt to improve upon the explanation of seeded acreage, it was believed important to take into account the influence of these technical relations.

Acreage Fallowed

In wheat and sorghum production, the alternatives of continuous cropping versus rotation with fallow present an economic problem. Farmers in Central and Western Kansas must decide how much land to fallow.

Fallowing increases the accumulation of moisture and helps control weeds. The moisture added through fallowing benefits the crops seeded on the land the following season, and in some areas, influences the crops planted two and three years later. In this area, moisture is an important production factor and fallowing usually increases the yields of future crops. The cost of fallowing is the loss of use of the land for a year plus the cost of tillage operations.

In a study by Knight (18) for selecting the superior frequency of fallow for wheat in Finney, Thomas, and Ellis counties, he found that wheat after fallow was superior in Finney and Thomas counties. His research also indicated that fallow and three years of wheat was the superior rotation for Ellis County. Ellis County is located near Barton County.

In a study by Knight and Hoffman (23) on the profitableness of fallow for milo production in Ellis, Finney, and Thomas counties, continuous milo was found to be superior for Finney County. Milo after fallow was found to be superior system in Thomas County, while the difference in returns was so small in Ellis County that one system could not be recommended over the other.

The total amount of land fallowed in a county for a year will depend on decisions farmers make at a number of points. Land fallowed in 1950 may come from land that was seeded to wheat the preceding fall but later abandoned and not planted to a spring crop, from land that could have been seeded to wheat but was not seeded, either to wheat or sorghum or other crops, or from land that was not available for wheat seeding and that was not seeded to a spring crop.

It was believed that the particular decision most influencing the acreage of fallow was the decision on acreage of wheat to seed in the fall. Because it was argued that rainfall in the second and third quarters (X_2) prior to seeding time and the price of wheat influenced the amount of wheat seeded, it would likewise be logical for those variables to appear in the fallow equation. As in the wheat seeding equation, a low value of X_2 or a low price of wheat would discourage wheat seeding because the prospective value of a crop would be low relative to its opportunity cost (value of a crop grown after fallow). Here, higher fallow acreages would be anticipated when the fallow avenue represents a high opportunity cost relative to profits from seeding. The acreage of wheat harvested the summer prior to seeding is explicitly a variable in this equation because it was believed that the opportunity cost of fallow will be relatively higher on this ground than on land in fallow prior to seeding and that a high proportion of the cropped land would be fallowed. It is not anticipated that much land fallowed the summer prior to seeding would be fallowed again unless moisture conditions were extremely unfavorable.

The acreage of sorghum harvested was related to acreage fallowed. This land can be planted to wheat only by fallowing or by growing some spring sown small grain as oats or barley. Not all of the sorghum land will be fallowed because some of it will be seeded to oats or barley and some will be seeded to row crops again (sorghum or corn).

The acreage harvested the preceding year, (all crops excluding prairie hay, and four-fifths of the alfalfa acreage) was used as a measure of county size. Other things remaining equal, the acreage of fallow would be greater in the larger counties, or it would be greater in the same county when a high proportion of the agricultural land was used for cultivated crops.

Fallowing is a new form of technology that was introduced and first used in this area during the over-all period of this study. Very little fallowing was practiced prior to 1930. Because there was a lag in adoption of this technique, it was necessary to add a time variable to the equation. The acreage fallowed has increased steadily through time.

Other studies indicated that fallow was a profitable practice in Finney County in many years, but that it was not so profitable in Barton County. It would be expected that the elasticity of acreage changes with respect to moisture, wheat price, and acreage of land in wheat prior to the time the decision on wheat seeding was made would be higher in Finney than in Barton County.

Wheat Harvesting and Abandonment

After wheat is seeded, the only other decision farmers make that influences the amount of wheat produced and the use to which land is committed is the decision concerning the acreage to harvest or not harvest (abandon). As before, they would be expected to abandon the crop if it did not promise to cover variable costs at that stage (combining, hauling, storage) and was not in excess of the promised returns from the best alternative use to which the land could be used--the opportunity cost of the crop at that time (spring or early summer).

The price of wheat is used as a variable in this equation because of its influence on the promised value of the crop. If the price of wheat is high, it would be reasonable that more wheat with low yield prospects would be harvested than would be the case if the price of wheat were low. A price relative (ratio of wheat and sorghum prices) was not used because it was believed that the opportunity cost of this crop was the value of a crop of wheat after fallow from this land a year later.

The influence of yield prospects, which are necessary data for the completion of the assessment of the value of the anticipated crop, were entered into the formulation. Yield prospects could not be represented directly. It was believed that yields are highly related to rainfall. The total amount of rainfall for the six-month period prior to seeding (X_2) and for the six-month period after seeding (X_5) were used instead of a more explicit measure of yields.

It was also hypothesized that the total acreage harvested was related to acreage seeded. It is expected that acreage harvested increases with increases in acreage seeded, but at a diminishing rate because it is reasoned that for years of large seeded acreage, some of the additional acreage will be on a less fertile land or land with less moisture content. These considerations would be reflected in lower yields for wheat seeded on land of this character. Perhaps a logarithmic or polynomial equation would have been more appropriate in this situation. In an alternative formulation, harvested acreage was related to acres of wheat seeded after a crop and acres of fallow. This formulation was used because it was believed that the proportion of the wheat harvested would be smaller for wheat seeded after a crop than for wheat seeded after fallow. This is basically a soil moisture problem again. It would be expected that the soil moisture content of the soil for wheat after wheat would be lower and consequently yields would be lower.

Regression equations were fitted with both acres harvested (Y_2) and acres abandoned (Y_7) dependent, where Y_7 = acres seeded $(Y_1)-Y_2$. Although the two equations with the respective dependent variables are very similar representations, the interpretation associated with them is widely different. With Y_2 as a dependent variable, the equation estimates the acreage harvested straightforwardly. With Y_7 dependent, the equation helps locate planning errors of farmers in an ex poste sense. The acreage of wheat abandoned represents errors--farmers planted wheat but failed to harvest it. They may have made the best decision based on their ex ante information when they decided to seed. At that time, the expected returns from a crop may have appeared sufficient to cover the variable costs and may also have given promise of exceeding the opportunity costs. Information coming after seeding time, concerning moisture and yields, prices, and profitability of alternatives suggested a different choice than did the information they used at seeding time. Some farmers may not have interpreted the information they had at seeding time properly, and others may be paying with this abandoned wheat the price of flexibility and the opportunity it provides for harvesting good crops in those years that the information becoming available after seeding time is favorable from the standpoint of profits from the current wheat crop. Here is objective evidence on farmers making the "Type I error," i.e., taking action when they shouldn't. It is not as easy in this study to analyze the "Type II error," i.e., not taking action when they should. These would be farmers who failed to plant wheat when they should have.

Studies of unharvested portions of a crop have been reported. Suits (14), pp. 239-240, related the quantity of watermelons harvested to the quantity available for harvest and a ratio of watermelon prices to wage rates. Suits and Koizumi (15), p. 478, related the unharvested crop of onions to the current price, harvesting cost, farm wage rate, and quantity available for harvest. Costs were not entered explicitly into the wheat harvest equations. The big cost of a crop is the opportunity costs and a cost index would affect the opportunity cost relatively about the same as the variable cost for the crop in question. Therefore, it could be reasoned that cost levels would not affect the relative profitableness of different alternatives, wheat crop remaining to be harvested, versus sorghum, wheat after fallow, etc. Costs would help determine whether the value of a crop would pay for the harvesting costs. Here, too, costs are more stable, and it would usually be the influence of fluctuations in yields and prices, factors determining whether a crop is worth harvesting, that would be detected by regression analysis.

All Sorghum and Grain Sorghum Harvested

Since there were no data on the acreage seeded to sorghums, decision equations comparable to either the wheat seeding equation or the abandonment equation were not possible. However, it was believed that the equation explaining the acreage of all sorghums and grain sorghums harvested would reflect some of the decisions that farmers make in regard to the planting of sorghums.

The land variables for this equation fall into three categories: acres of all crops harvested the previous year, or X_{18}; the acres of wheat abandoned in the spring, or Y_7; and the acres of wheat seeded the previous fall, or Y_1.

The acreage of all crops harvested was used to give an indication of county size or total cropland available. As noted in the decision pattern, sorghum could be planted on all land except that planted to wheat and the wheat not abandoned. For that reason, Y_1 and Y_7 were included in the formulation. It was believed that a large proportion of the abandoned wheat land was planted to sorghum, expecially if the opportunity cost (value of a crop of wheat after fallow) is less than the expected value of the sorghum crop. The price ratio of sorghum and wheat was used to detect the influence of the expected profitability (aside from yields and costs) of sorghum and wheat after fallow on the acreage of sorghum.

Once a crop of sorghum is seeded, and if it appears it has little possibility of covering the costs of harvesting, it is reasonable to believe that farmers would abandon the crop and divert this land to wheat, either seeded that fall or fallowed for seeding a year later. But this is dependent on the amount of moisture received during the crucial period of the sorghum growing season. Although it was not possible to draw upon results from other studies or upon a priori knowledge, it appeared reasonable to use the total precipitation received for the three-month period of July 1 to October 1, or X_9, for this variable. Because all of the sorghum would be planted by July or soon thereafter, this measures indirectly the amount of abandonment and puts the equation in an acres harvested form. Without this variable, the equation would be appropriate for explaining seeded acreage, not harvested acreage, the only acreage that could be estimated.

To take into account the effects of those variables changing with time but not measurable, the variable time was added.

The above variables were used in different formulations to explain both the total acreage of sorghum harvested and acres of grain sorghum harvested.

No measure of fall and winter precipitation was used in these equations. Although it was believed that this moisture would increase the prospective value of a sorghum crop, it would probably increase the prospective value of a sorghum crop less than the opportunity cost of a crop of wheat after fallow.

It is believed that farmers in Central and Western Kansas would prefer to grow wheat. Some farmers produce sorghum for livestock feed, and some probably grow some sorghum for the risk reduction possibilities associated with diversification. Otherwise, it is hypothesized, sorghum is produced largely in those instances in which its opportunity cost is low relative to profits from wheat production. Farmers have equipment, storage facilities, and technical knowledge better adapted for wheat production, but sufficiently versatile that sorghum can be produced. The variability of yields is greater for sorghum than for wheat, and sorghum does not provide as much pasture as wheat. Unless proper tillage practices are followed, erosion both from water and wind, is a greater problem with sorghum than with wheat.

PRODUCTIVITY OF RESOURCES

The total amount of wheat or sorghum produced is determined by the quantity of resources committed to their production and by the physical productivity of these inputs. To complete the study of production, it is necessary to analyze the forces behind the productivity of resources used to produce these crops. Because value productivity (of which physical productivity is a part) influences the allocation of resources, the decision equations and the productivity equations will manifest marked similarities. In many cases, variables will appear in both and the logic behind their use will be parallel in the two types of equations.

By studying the productivity of the various resources committed, it is possible to attach valuations to the different resources, and insights will be gained relative to farmers' use of appropriate strategies under similar conditions.

Wheat Production

It was hypothesized that wheat production was primarily reflected through the amount of rainfall and land committed to it. The acreage of land committed to wheat production falls into two categories; land that had been fallowed, or Y_6, and land on which a crop had been harvested the previous year, or Y_9. The amount of each of these categories of land committed was determined by the decisions made at various dates.

The acreages Y_6 and Y_9 were not aggregated into one acreage total since it is generally believed that land in the two categories is different. To argue this, the difference in wheat yields between wheat on fallowed and continuous wheat was inspected for the two counties. The only data available were for the years 1947-54, but it is reasonable that this eight-year period could be an indication of what could be expected for the whole period. In Finney County, the average acre yield of wheat on fallowed land was 13.8 bushels compared to 10.0 bushels for continuous wheat. In Barton County, the yields were 18.2 bushels for wheat on fallow compared to 13.3 bushels for continuous wheat (20). In the study by Knight (18), p. 30, it was found that when residual effects were recognised, the optimum rotation for Ellis

County included fallow and three crops of wheat.

If soil moisture readings would have been available at seeding time, an aggregate measure of land committed to wheat production would have been used where measures of acres and moisture would both have been reflected. Lacking these measures of soil moisture, land was grouped as described above.

As stated in the hypothesis, moisture was believed to be the other factor determining wheat production. It appeared reasonable to aggregate the moisture received into three categories: moisture received for a six-month period from April 1 to October 1, one year prior to seeding time, or X_{2t-1}; moisture received for a six-month period from April 1 to October 1, just before seeding time, or X_2; and moisture received for a six-month period after seeding from October 1 to April 1, or X_5. The variables X_2 and X_5 enter this equation with the same logic as in the wheat harvesting and wheat abandonment equations; X_{2t-1} enters because it is believed that the amount of rainfall received in this period influenced the amount of soil moisture, expecially the subsoil moisture. It is generally known that successive dry years or successive wet years are cumulative in their effect on the amount of moisture in the soil. The amount of moisture in the soil, where a dry year followed a wet year, is greater than for two dry years, but less than for two wet years.

One of the main factors affecting wheat production is the stand and early growth obtained, and this is a result of the amount of soil moisture at seeding time. It was not known exactly what period of rainfall should be used for soil moisture, or how it should be used. Since most of the annual rainfall for Central and Western Kansas falls during the six-month period of April 1 to October 1, it seemed reasonable to use the total precipitation of this period. Even though some of the April, May, and June rainfall would be used on the land which a crop had been harvested the previous summer, some of the moisture would remain in the soil.

The third measure of moisture used in this formulation was the six-month period following seeding time, October 1 to April 1. Although the amount received during this period is usually small, this moisture is suspected to contribute in explaining wheat production. This may be especially true if there was little soil moisture at seeding time. In addition to the direct relationship on production, it was believed that the moisture received in this period would eliminate soil blowing and wind erosion thereby having an indirect relationship on production.

Within the time period the study covered, improved varieties of wheat have been seeded in this area. Varieties have been introduced that are resistant or immune to the various diseases that reduced wheat yields in earlier years. To take into account this improvement in technology, an index of yield ability (X_8) was included in this equation.

Not all of the factors having an influence on wheat production could be represented in this formulation. It was not possible to specifically represent the improvements in technology, such as mechanization and tillage operations. To take into account the influence of these factors, a time variable was added to the formulation.

No variable reflecting the influence of price appears in the formulations. Price was hypothesized to influence the acreage and moisture committed to wheat production, but these variables are given in this equation. Once wheat has been seeded, there are few decisions farmers can make that influence production. The sole exception is the decision on acreage harvested. Here, it was argued that price was important, but even so, it would suggest to farmers that the wheat with lower yield prospects be abandoned, and it is not believed that the decision to abandon a large acreage because of price would influence production appreciably. For the period studied, inputs that might be varied easily in response to price, as fertilizer and irrigation, were used very little in this area. It is anticipated that a considerable acreage will be both fertilized and irrigated in the future.

Alternative forms of the relation were studied. A function linear in actual values of the variables and a function linear in logs of the variables were tested. The logarithmic function was studied because it was believed the productivity of some of the resources was at a diminishing rate, and that the marginal productivity of some resources was related to the quantity of other resources employed.

It is known that not all of the factors influencing wheat production are explicit in the equation. These variables either were not measurable, or it was not known how to aggregate them. Examples include hot winds, hail, insects, disease, floods, rains at harvest impeding or preventing harvest, and weeds. It was assumed that their influence was random, and it is likely that this was at least approximately the case and that there is no bias in the results associated with the influence of these factors not studied.

Wheat Yields

The objective of these equations was to derive productivity estimates for a fixed technical unit. The equations were set up with land the technical unit, and output was measured in terms of yield per harvested acre, Y_3. To represent the influence of fallowing on wheat yields, the percentage of wheat seeded on fallow (X_{14}) was used as a variable. Except for the use of Y_3 for Y_8, and X_{14} for Y_6 and Y_9, the yield formulations were identical to the production formulations, including the analysis of the alternative forms (functions linear in actual values and functions linear in logs).

Grain Sorghum Yields

A production function was derived to determine the factors that affect the average grain sorghum yield per harvested acre. An acre of land again was used as the fixed technical unit. The hypothesis for this formulation was that the yield of grain sorghums was primarily reflected through the amount of moisture and fallowed land committed to it.

The moisture variables for this formulation were grouped into three categories: precipitation for the six-month period April 1 to October 1 of the preceding year, or X_2; precipitation received for the six-month period from January 1 to July 1, or X_{10}; and precipitation received for the three-month period from July 1 to October 1, or X_9.

If readings of soil moisture would have been available at seeding time, they, plus the moisture received after seeding, would have been used. These readings were not available, and precipitation variables were substituted. As discussed above for the wheat seeding formulation, knowledge was not at hand as how to treat these precipitation variables used as an indication of soil moisture. However, it seemed reasonable to use X_2 as an indication of soil moisture as in the wheat production formulation. It is reasoned that X_2 will serve as a measure of the amount of subsoil moisture available for sorghum.

The amount of precipitation received for the six-month period from January 1 to July 1 was believed, together with X_2, to influence, to a large extent, the stand and early growth obtained. Although the variable is inconsistent with the variables of previous formulations, by the fact that moisture received before and after seeding was combined, it was not believed that this would affect the results appreciably.

Although soil moisture at seeding and moisture immediately after seeding affect yield indirectly by the stand that is obtained, it was believed that the moisture received in the mid-summer months had the largest influence on yields. To take into account the effect of this moisture, the total precipitation for the three-month period from July 1 to October 1 was used.

Another factor that was believed to influence yields was the amount of sorghum seeded on fallow. In a study by Knight and Hoffman (23), p. 40, it was found that a per acre yield for continuous milo and milo after fallow differed by 9.75 bushels in Finney County and by 14.97 bushels in Ellis County. Although these data were from controlled experimental plots, it is reasonable to believe that the county results would be somewhat similar. No data were available as to the acreage seeded on fallow, but it was believed to be quite small. However, due to the difference in yields, even a small acreage of sorghum seeded on fallow could increase the average yield. Since there were no data on the acreage of sorghum seeded on fallow, and a complete *a priori* knowledge was not at hand, it seemed reasonable to use the total acreage fallowed the previous year on the assumption that the acreage of sorghum seeded on fallow would be reflected by this variable.

Not all the factors influencing sorghum yields could be represented in the formulation. These include a wide variety of technological improvements such as mechanization, disease treatment, tillage practices, and varieties. To take into account the influence of these factors, which are assumed to have changed at a constant rate over time, a time variable was added to the equation.

The other possible factors, whose influence was not studied but was assumed random, could be listed here as for the wheat production formulation. Again, it is believed that the results remain unbiased.

EMPIRICAL RESULTS

For each formulation studied, the following information was presented: R^2, "a"(the Y intercept), units of measure for all variables, mean values for all variables, "b's" (coefficients), and "t" values for all independent variables.

The results for the abandonment equation, $Y_7 = f(X_2, X_5, X_3, Y_1)$, Finney County, are interpreted. The results for other equations would be interpreted similarly. Units of measure for Y_7, X_2, X_5, X_3, and Y_1 were thousands of acres, tenths of inches, tenths of inches, dollars per bushel multiplied by 100, and thousands of acres, respectively. The value of Y_7 can be predicted by adding to "a" the inner product of the b's and the quantities of independent variables, measured in the units defined above. For all variables measured at the means, $Y_7 = 65.540500 = 124.210672 - 0.452562 (139.783800) - 0.669699 (48.054100) - 0.239098 (132.513500) + 0.352425 (194.243200)$. It is not necessary that mean values be employed. Any values for independent variables that are within the range of the data may be used, but the standard errors for the predicted values are minimum for predictions based on mean values of all variables.

The interpretation of the coefficients is illustrated as follows: an increase in X_2 (inches of rainfall the previous April 1 to October 1 period) by one unit (one tenth of an inch) decreased abandonment by 0.452562 units (thousands of acres) or 452.562 acres, on the average, for the period 1917-53, with the effects of other independent variables given. Similarly, for the effects of other independent variables held constant, an increase in X_5 by a tenth of an inch was associated, on the average, with a reduction of 669.699 acres of wheat abandoned. Increases in X_3 by a unit (one cent) were associated with a reduction of 239.098 acres abandoned, the effects of X_2, X_5, and Y_1 being taken into account. Lastly, increases in Y_1 by one unit (thousand acres) were associated with an increase in acreage abandoned of 0.352425 units (in thousands of acres) or 352.425 acres. With effects of other variables held constant, decreases in X_2, X_5, and X_3 were associated with increases in Y_7, and decreases in Y_1 were associated with increases in Y_7.

Equation 12 is linear in logs. The coefficients for the independent variables are elasticities, and each coefficient indicates (assuming the effects of other variables are held constant) the percentage change in Y_5 associated with a one percent change for the variable under examination. For example, in the equation for Barton County, $Y_5 = f(X_9, X_{10}, X_2)$, a one percent change in X_2 was associated, on the average, with a 0.793505 percent change in Y_5, the effects of X_9 and X_{10} remaining fixed.

Equations 8 and 10 are mixed, that is, some coefficients are for variables converted to logs, and some coefficients are for actual values of the variables. For Equation 6, Barton County, $X_8 = f(X_2, Y_9, Y_6, X_{2t-1}, X_{15})$, the coefficient for X_2 (where X_2 is in logs) indicates that a one percent change in X_2 was associated with a 0.343376 percent change in Y_8. The coefficient for X_{15} indicates that a one unit change in X_{15} (a change of one year) was associated with a change of 0.015378 units of Y_8, where a unit of Y_8 is the log of hundreds of bushels.

In some cases several formulations of each equation were studied. If a variable was used in a particular formulation, a "b" and "t" value will appear in the row for the formulation and in the column for the variable. If a variable was not used in some particular formulation, no "b" or "t" value will appear in the cell where the row for the formulation and the column for the variable intersect. For example, for the abandonment equation, Function (a) X_2, X_5, X_3, Y_6, and Y_9 were used as independent variables, and the consequent values for R^2 and "a" were 28.45 percent and 1962.392161, respectively. However, for Function (b), only X_2, X_5, and X_3 were used while Y_6 and Y_9 were not used. With only the effects of these three independent variables studied, $R^2 = 23.35$ percent and "a" = 1243.623191. Throughout the tables, R^2 was measured in percent, and "a" was measured in the same units as the dependent variable except for Equations 8 and 10, where "a" is left in log form and the true intercept would equal the antilog of the log given.

Wheat Seeding

The formulation used to explain variations in seeded acreage of wheat for Finney County, 1917-53, accounted for nearly 87 percent of the sum of squares of seeded acreages about the mean. Some of the coefficients were reasonable statistically and logically; others were not. Effects detected for harvested cropland available for wheat (X_{12}), acres of wheat abandoned (Y_7), and time (X_{15}) were consistent with the hypotheses. The coefficient for acres fallowed (Y_8) was not logically acceptable. It was hypothesized that fallowed land would tend to increase the acreage seeded. However, Y_8 was highly correlated with X_{15}, (0.902409) making their separate effects difficult to detect. The coefficients for rainfall prior to seeding (X_2) and the price of wheat (X_3) were neither statistically acceptable nor plausible.

In the short-run, farmers in Finney County apparently respond to the stocks of resources in deciding how much wheat to seed. No evidence was detected that farmers react to the prospective value of the crop at seeding time, as reflected by X_2 and X_3.

Three functions were used to explain acreage of wheat seeded for Barton County, 1917-53. The success of these regressions, as measured by R^2, was limited in each case. The coefficients were not stable among functions, and many of the coefficients were satisfactory neither on a priori grounds nor on statistical grounds. Among the three trials, the value of R^2 was necessarily largest for Function (a) $Y_1 = f(X_2, X_{15}, X_3, X_{12}, Y_7, Y_6)$, but only two coefficients were significant and one of them was not logical. The negative coefficient attached to Y_6 is not believed to describe the real relation.

Function (b), $Y_1 = f(X_2, X_{15}, X_3, X_{12}, Y_7)$ explained a smaller percentage of the total variation, but the coefficients for X_3, X_{12}, and Y_7 were more acceptable than in Function (a). Function (c) was not satisfactory.

Because the functions for the entire period 1917-53 for Barton County were not considered satisfactory, the period was divided into three sub periods and functions were fitted for each of the separate periods. The number of degrees of freedom for each period was small.

1917-1930. This was a period of largely horsedrawn machinery, no fallow, and declining wheat prices. The formulations for this particular period were not adequate. Except for the coefficients attached to X_{15} in the two functions, none of the coefficients were statistically different from zero.

1931-1940. This was a period of improvement in technology, expecially mechanization and fallowing. It was also a period affected considerably by drought and low wheat prices.

Functions (a) and (b) were the only satisfactory formulations used for

Barton County. With the exception of the implausible and unexplainable signs attached to coefficients for X_2, the coefficients reflected relations as hypothesized. In this period, farmers responded to price and resource stocks (land measured by X_{12} and Y_7). It is clear that they responded to Y_7. Function (c), where Y_7 was not used, was not satisfactory. Although little can be generalized from Functions (a) and (b), as there are only three and four degrees of freedom, respectively, there is evidence that during the depression these farmers responded to price.

1941-1953. The improvement in technology continued, but rainfall amounts and wheat prices were above the 1931-1940 levels. In the effort to explain wheat production during this war and post-war period, a value of 89.80 percent was obtained for R^2. However, illogical coefficients were obtained for this formulation. This was undoubtedly due to the high intercorrelation between a number of the variables, making it impossible to isolate the effects of changes in the independent variables.

The formulations used to explain seeded acreage were at best only a modest improvement over the work by Bowlen. There was little evidence that farmers responded to the prospective value of the crop, as reflected either by price or soil moisture. There was considerable evidence that they responded to average resource stocks, especially Y_7 and X_{12}. The acreage of Y_7 is explained in another equation. The explanation of X_{12} would involve a more long-run type of study than was undertaken here.

Acreage Fallowed

Variations in the acreage of fallow, 1931-1953, were more completely explained for Finney than for Barton County. Values for R^2 for Finney County were approximately 85 percent in all formulations derived, but were only 49.17 to 29.23 percent in Barton County. Coefficients were stable and logical for precipitation, X_2, acreage of all sorghums harvested the previous year, X_{11}, and time, X_{15}, for Finney County and only for price, X_3, for Barton County. Fallowing was more important in Finney County, both in terms of acres and percentage of total cropland.

A previous study demonstrated that profits from wheat after fallow were greater than from continuous wheat, but that there were years the former was more profitable and that there were other years that the latter method was superior. In some of the years, profits from continuous wheat were considerably greater than from wheat after fallow. Therefore, it is plausible that farmers in Finney County would be responsive in their use of fallow to the stimuli studied here.

Other things being equal, in Finney County the acreage fallowed decreased with increases in rainfall prior to wheat seeding, and vice versa, and the coefficient was large relative to its standard error. In Barton County, no effect of rainfall prior to seeding time on acreage fallowed was detected. This relation is quite reasonable. Precipitation in Barton County from April 1 to October 1 averaged 17.9 inches for the period 1931-1953, which was considerably greater than the 13.3 inches average in Finney County, and the average amount coming after seeding time was measurably greater. In Finney County, where the average precipitation is less, the amount of rainfall prior to seeding plays a crucial part in explaining how much land will be fallowed. Farmers in Barton County apparently seed even when the soil is dry because fall and winter precipitation is greater than in Finney County, and a good crop could still be harvested.

In the formulation in which the price of wheat was included, R^2 was increased by 6 percent for Barton County, but studying the effects of price did not increase R^2 for Finney County. The price coefficients for Barton County were significant at 20 and 5 percent levels, while the coefficients for Finney County were not significant at the 50 percent level. There is evidence that farmers in Barton County consider the price of wheat in making their decisions on the amount of land to fallow. Farmers in Finney County apparently responded more to yield prospects, as reflected by precipitation, than to price in deciding whether to seed wheat or to fallow.

The coefficients for acreage of sorghum harvested the previous year were positive and significant at the 10 percent level for the formulations for Finney County. For Barton County, the coefficients were negative, but significant at the 30 and 50 percent levels. However, since precipitation is the crucial factor in Finney County, it is quite reasonable that most of the sorghum land would be put into fallow. In Barton County, where there is a higher winter and spring rainfall average, this land was probably sown to other crops and not left for fallow.

The coefficient for acres of wheat harvested the previous year (Y_2) was not significant at the 50 percent level for Finney County, but was more precise for some formulations for Barton County. The previous study cited above indicated that the optimum amount of fallow in the Barton County area was fallow after three crops of wheat. Perhaps a variable reflecting the acreage of wheat for a period longer than a year, perhaps three years, would have improved the formulation. However, the negative coefficient for acres for all crops harvested (X_{18}) was significant at the 10 percent level for Barton County, but was not significant even at the 50 percent level for Finney County. There is no apparent explanation for the Barton County relation. It would be expected that increases in total crop acreage harvested would be followed by an increased acreage of fallow.

The coefficient for time was large relative to its standard error in Finney County, and was significant at the one percent level. In Barton County, the coefficients were rather unstable from function to function, and there was no clear trend in the amount of land fallowed through time after the effects of other variables were taken into account.

Evidence was detected that farmers in Finney County increased the acreage of land fallowed through time. It is also evident that the moisture received prior to wheat seeding time is highly associated with land fallowed. With a low value of X_2, more land is fallowed because the prospective value of a crop is low relative to its opportunity cost (value of a crop after fallow). Further evidence was detected for price in Barton County. With a prospect for higher wheat prices, these farmers fallowed less, deciding that the prospective value of a crop was more than the opportunity cost of fallowing. There was no evidence that farmers in Barton County responded to any of the other conditions studied. The simple correlation coefficients for Y_6 and other respective variables were all negative.

The influence of X_2 for Finney County and of X_3 for Barton County on acreage fallowed did not parallel the results from the study of wheat seeding, where no measurable effects for these variables were detected. Consistent results were obtained for X_3 for Finney County and X_2 for Barton County, because these variables showed no influence upon either Y_1 or Y_6.

Wheat Harvesting

The precision for predicted values for acres of wheat harvested (Y_2) was higher for Finney than for Barton County. Values for R^2 were approximately 60 percent for Finney County, but ranged from 18 to 50 percent for

Barton County. Precipitation and acreage seeded variables more completely explained variations in acreage harvested in Finney County.

In light of the hypotheses stated, the coefficients of the precipitation variables were of the appropriate sign. Other things being equal, the acres harvested increased with increases in rainfall prior to seeding (X_2) and with increases in rainfall after seeding (X_5) and vice versa. For Finney County, both coefficients were large relative to their standard errors, but in Barton County, the t-ratios for X_5 were significant at the 5 percent level, while the t-ratios for X_2 were significant at approximately the 30 percent level. However, this relationship is quite reasonable, since the rainfall in Barton County from October 1 to April 1 averaged 6.30 inches for the period 1917-53, which was considerably greater than the 4.81 inch average in Finney County. It seems, on the average, that precipitation after seeding goes further in explaining what happens to a crop in Barton County. But in Finney County, where fall and winter precipitation was less, the amount of precipitation in both periods was crucial in explaining the outcome of the crop.

The influence of price (X_3) on acreage harvested was as hypothesized (as price increased, the acres harvested would increase), but for both counties and all formulations the standard error of the coefficients was relatively large. For Barton County, the coefficients were significant at the 30 percent level, while in Finney County, they were significant at the 30 and 20 percent levels. Thus, there is some evidence that farmers in their decisions whether or not to harvest, use price in appraising the value of the wheat crop in relation to opportunity cost.

The coefficients for acreage seeded, either total acres (Y_1), or in the alternative formulations where acres seeded after fallow (Y_6) and acres seeded after a crop (Y_9) were used as independent variables, were reasonable and had the appropriate sign for both counties. The acreage harvested was directly related to acres seeded, even after a correction had been made for soil moisture at seeding time for both counties. When the acreage seeded was divided into Y_9 and Y_6, harvested acres was related somewhat more to Y_9 than Y_6.

For Finney County, total acres seeded did not increase the value of R^2 after the effects of X_2, X_5, and X_3 had been taken into account. The coefficients for the other variables were slightly higher for this function, but the change was quite small. For the Barton County formulation, where the effects of Y_6 and Y_9 were studied, the value of R^2 was increased by 3.60 percent when the effects of these variables were added, and the values of the coefficients for these other variables were slightly higher.

Evidence was detected that farmers associate the prospective value of a crop with its opportunity cost in making a decision on harvesting. The influence of yield factors, as reflected by the precipitation variables and by the acreage seeded variables, were detected for both counties. Further evidence was detected for price, although it was less decisive.

Wheat Abandonment

The efforts to explain the acreage of wheat abandoned (Y_7) were more successful for Finney than for Barton County. Values for R^2 were approximately 48 percent for Finney County, but were only 23.35 to 28.45 percent in Barton County. Precipitation and acreage seeded variables more completely explained variations in acreage abandoned in Finney County. Acreage abandoned was more important in Finney County both in terms of acres and as a percentage of seeded acres of wheat.

The coefficients for the precipitation variables were of appropriate signs (in light of the hypotheses advanced). Other things being equal, the acreage abandoned increased with decreases in rainfall prior to seeding (X_2) and with decreases in rainfall after seeding (X_5), and vice versa. For Finney County, both coefficients were large relative to their standard errors, but in Barton County, the t-values for X_5 were significant at the 2 percent level, while the t-values for X_2 were significant at approximately the 30 percent level. This relation is reasonable. Rainfall in Barton County, October 1 to April 1, averaged 6.30 inches during the period 1917-53, which was considerably greater than the 4.81 inch average in Finney County. Therefore, on the average, rainfall after seeding goes further in explaining what happens to a crop in Barton County. In Finney County, where fall and winter precipitation averaged less, the amount of rainfall for both periods was crucial in explaining the outcome of the crop.

The influence of price (X_3) on acreage abandoned was as hypothesized (higher valued crops should be left for harvest), but for all formulations, for both counties, the standard error of the coefficients was large. The coefficients for Barton County were significant at the 40 percent level, while the coefficients for Finney County were significant at 30 and 20 percent levels. Thus, some evidence was detected that farmers make a decision regarding leaving the wheat for harvest, by using price to appraise the value of the wheat crop to compare to opportunity costs.

The coefficients for acreage seeded, either total acres (Y_1) or in the alternative formulations, where acres seeded after fallow (Y_6) and acres seeded after a crop (Y_9) were used as independent variables, both were more reliable and more reasonable for Finney County. For this county, the acreage abandoned was directly related to acres seeded, even after a correction had been made for soil moisture at seeding time. When acreage was disaggregated, abandonment was related to Y_9 more than to Y_6, but the difference was not pronounced.

For Barton County, total acres seeded did not increase the value of R^2 after the effects of X_2, X_5, and X_3 had been taken into account. For the formulation in which the effects of Y_6 and Y_9 were studied, the value of R^2 was increased by 5.10 percent when their effects were added. The values of coefficients for other variables were slightly higher when these acreage variables were added, but the alteration was of limited extent. The coefficient for Y_9 was not significant at the 50 percent probability level. The negative coefficient for Y_6 (which means that acreage abandoned decreased with increases in Y_6) was significant at the 20 percent probability level. Because the correlation of Y_6 and Y_9 was extremely large (-.812388), the effects of changes in Y_6 and Y_9 cannot easily be isolated. As Y_6 increased, Y_9 decreased, and changes in Y_7 cannot easily be associated with changes in Y_6 and Y_9 separately.

Evidence was detected that farmers associate the prospective value of a crop with opportunity costs in making a decision on abandonment. The influence of yield factors, as reflected by the rainfall variables, were detected for both counties and as reflected by the acreage seeded variable in Finney County. Further evidence, although less decisive, was detected for price.

The evidence on the Type I error was more clear for Finney County. In this county, higher acreages of abandonment were associated with seeding on dry soil, as measured indirectly by X_2, Y_6, and Y_9, or Y_1. In Barton County, some association of abandonment and X_2 was detected, but most of the information farmers used apparently was not available at seeding time. For example, X_5, a measure of fall and winter precipitation, would not be known at seeding time.

For the period studied, approximately one-third of the wheat seeded in Finney County was abandoned. This is considered a high percentage and makes valuable explanations for this occurrence.

All Sorghums Harvested

The acreage of all sorghum harvested was predicted for Finney County and for Barton County. Values for R^2 were 67.28 to 76.65 percent for Finney County and somewhat lower for Barton County. Precipitation and acres of wheat abandoned the previous spring more completely explained acreage of all sorghums harvested in Finney County. Acreage of sorghum was more important in Finney County.

The coefficient for the precipitation variable was of the appropriate sign. Other things equal, the acreage of sorghum harvested increased with increases in precipitation (X_9) and vice versa. For Finney County, the coefficient was large relative to its standard error and was significant beyond the one percent level, but in Barton County the t-value for X_9 was not significant at the 50 percent level. This relation is reasonable, since rainfall in Barton County averaged 8.2 inches during July 1 to October 1 for the period 1917-1953, which was considerably more than the 6.4 inch average in Finney County. Therefore, in Finney County, where the summer precipitation averaged less, the amount of rainfall was crucial in explaining the acreage of the crop harvested even after corrections had been made for the effects of other variables.

The coefficients for acres of wheat abandoned the previous spring (Y_7)

and acres of wheat seeded (Y_1) were statistically and logically acceptable for both counties. In both counties, the acreage of sorghum harvested was directly related to acres of wheat abandoned with the t-values being significant beyond the one percent level and as hypothesized, the acreage of sorghum harvested decreased with increases in acres of wheat seeded. The t-values were significant at the 10 percent level for the coefficient for this variable for both counties. Practically no evidence was detected that the acres of all crops harvested the previous year (X_{18}) influenced the acreage of sorghum harvested after the effects of acres of wheat seeded and acres of wheat abandoned were taken into account. Thus, X_{18}, used in this study as a measure of size of county, showed no observable influence. Due to the importance of precipitation, it is reasonable to believe that the acreage of sorghums harvested would be decreased by a large acreage of all crops being harvested the previous year, because it was reasoned that a large part of this land was fallowed.

The influence of the sorghum-wheat price ratio on sorghum acreage harvested was as hypothesized (higher valued sorghum crops would be left for harvest), but the standard error for the coefficients was large, especially for Barton County. The coefficient for Finney County was significant at the 20 percent level. Thus, some evidence was detected that farmers in Finney County use prices to compare the value of the sorghum crop to its opportunity cost in determining the acreage of sorghum to harvest, where the acreage harvested is actually determined by the difference between the measures, acres seeded and acres abandoned, for which there were no data.

The coefficient for time (X_{15}) was significant in both counties beyond the one percent level, indicating that the influence of the factors represented by time have influenced the acreage of sorghum harvested.

An alternative formulation for Finney County was to drop the time variable (X_{15}). The reason for studying this function was that X_{15} was highly correlated with some of the other independent variables. This lowered the value of R^2 to 67.28 percent, but did not change any of the coefficients or the t-values appreciably.

Evidence was detected that farmers associate the prospective value of a crop with its opportunity cost in making a decision on harvesting. The influence of yield factors, as reflected by the rainfall variable and price, was detected for Finney County. It was also detected in both counties that the acreage of sorghum harvested was directly related to the acreage of wheat abandoned the previous spring.

Grain Sorghum Harvested

The formulations to explain acreage of grain sorghum harvested were not as successful as the formulations for all sorghums harvested. Values of R^2 were 26.14 to 37.93 percent for Finney County and 41.85 percent for Barton County. A better degree of fit was obtained for Barton County in this formulation while the opposite was true for the previous formulation, where X_{13} was dependent.

For Finney County, the coefficient for X_9 was large relative to its standard error and was significant at the 2 percent level, and in Barton County the t-value for X_9 was significant at the 20 percent level. However, there is little difference between the two coefficients in the amount they affected acres harvested.

In both counties, the acreage of grain sorghum harvested was directly related to acres of wheat abandoned (Y_7) and acres of wheat seeded (Y_1), with the t-value of Y_7 being significant at the one percent level in Barton County and at the 20 percent level in Finney County. Coefficients for Y_1 were significant at the 10 percent level in Finney County and at the 40 percent level in Barton County.

After acres of wheat seeded and acres of wheat abandoned were taken into account, X_{18}, a measure of county size, showed some influence on the amount of grain sorghum harvested in Finney County. More evidence was detected for the influence of X_{18} on the acreage of grain sorghum harvested for Barton County, where the t-value for this coefficient was significant at the 10 percent level.

The influence of the sorghum-wheat price ratio was quite similar in this formulation as in the previous formulation with the standard errors of the coefficients extremely large. Some evidence was detected in Finney County that harvested acreage of grain sorghum was related to price.

The coefficient for time (X_{15}) was significant at the 2 percent level for both counties, indicating that the factors represented by time influenced the acreage of grain sorghum harvested.

An alternative formulation was derived for Finney County by dropping the time variable (X_{15}). The reason for studying this function was that X_{15} was highly correlated with several of the other independent variables. This lowered the degree of fit ($R^2 = 26.14$) and did not change any of the coefficients or t-values to any extent.

For both counties, it was detected that precipitation, time, and acres of wheat abandoned influenced the acreage of grain sorghum harvested. Further evidence, although less decisive, can be attributed to the acreage of wheat seeded.

Wheat Production

Linear Function. For the linear functions used to explain wheat production for the two counties, the following may be generalized: (1) precipitation, prior to seeding, X_2, a year prior to seeding, X_{2t-1}, and after seeding, X_5, all were associated with wheat production, and (2) wheat production was not explained by acres of wheat seeded after a crop (Y_9) and by acres fallowed (Y_6).

The coefficients for rainfall prior to seeding and for rainfall after seeding were significant for all formulations at the 5 percent probability level or higher. Rainfall during the six-month period one year prior to seeding (which is believed to reflect subsoil moisture conditions) was associated more closely with wheat production in Barton County than in Finney County. The latter county contains a large amount of sandy soil, and possibly subsoil moisture is not accurately reflected by X_{2t-1} because of the more limited moisture holding capacity of some soil in this county.

There was evidence of an increase in wheat production through time, especially for Finney County. However, the results were somewhat difficult to interpret because Y_6 was highly correlated with Y_9 and X_{15} in Barton County and X_{15} in Finney County. Although the equations are satisfactory for prediction purposes, it is not possible to isolate the separate effects of these variables.

An index of yield ability (X_6) was used for Barton County. The index was highly correlated with Y_6 and X_{15}, and the variations in X_6 were small. For those reasons, no meaningful results were obtained as a result of studying the effects of this variable. Formulations were studied in which X_5 was excluded. Deleting this variable leaves only variables whose values were known at seeding time. A predicting equation with variables known at seeding time can thus be compared with formulations containing this variable whose value is determined after seeding.

Rainfall after seeding explained more of the variations in production for Barton County than for Finney County, and those results are consistent with those obtained for other equations in this study. For Barton County, values of R^2 were 24.88 percent and 54.08 percent without and with X_5, respectively, while the values for Finney County were 53.03 percent and 62.07 percent. Thus, the additional variation explained by X_5 was considerably greater for Barton County.

Logarithmic Function. Although the values of R^2 for the logarithmic functions were higher than for the corresponding linear functions for both counties, coefficients were generally smaller relative to their standard errors and, in many cases, not so reasonable. For Barton County, none of the coefficients for rainfall variables were significant in these formulations. For Finney County, coefficients for X_2 and X_5 were reasonable, but the coefficients for X_{2t-1} were not acceptable. Most of the coefficients for Y_9 and Y_6 were negative, and these, as well as the negative coefficient for X_6, were not logical. As with the linear function, the intercorrelation of a number of independent variables explains the erratic character of some of the coefficients.

The acreage of fallow was zero for a number of the early years. This type of function is not accurate when some variable is zero (unless the resource is limitational). The reason is that the predicted value of dependent variable is zero when any independent variable (in log form) is zero by the nature of the function. This, too, helps explain the unsatisfactory results obtained for the effects of Y_6.

Formulations with a correction for the effect of X_5 (function "b" for Barton County, function "a" for Finney County) differed but little from functions with X_5 deleted. This was true for R^2, the sign and magnitude of the coefficients, and the t-ratios.

Wheat Yields

Linear Function. The linear formulations explained wheat yields roughly equally well for the two counties. Values of R^2 were approximately 20 to 47 percent for Barton County and 37 to 44 percent for Finney County.

For both counties, the coefficients for X_2 and X_5 were large relative to their standard errors. The t-value for X_{2t-1} was significant at the 20 percent level for Barton County, but was not significant at the 50 percent level for Finney County. These coefficients indicate, with the effects of the other independent variables unchanged, that yield increased with increases in any or all of the precipitation variables (except X_{2t-1} for Finney County), and vice versa.

The coefficient for percentage of wheat seeded on fallow (X_{14}) was more reliable and reasonable for Barton County than for Finney County. For this county, wheat yield was directly related to the percentage of wheat seeded on fallow, even after corrections had been made for the precipitation variables. For Finney County, the coefficient for X_{14} was significant at the 30 percent level; however, this coefficient was negative, which means that wheat yield (Y_3) decreased as X_{14} increased. This does not agree with experimental results and other secondary data. Because the correlation of X_{14} and X_{15} was extremely large (0.630911), the effects of changes in X_{14} and X_{15} cannot be easily isolated, probably causing the unrealistic coefficient for X_{14}.

For Finney County, the coefficient for the time variable was significant at the 5 percent level, but was not significant at the 50 percent level for Barton County.

An alternative function was derived by dropping X_5 from the formulations. The reason for dropping X_5 was that a function could be derived that would explain wheat yields at seeding time. Correcting for the effects of X_5 did not change appreciably the coefficients or t-values for other variables, but increased the value of R^2 considerably for Barton County.

The influence of an index of yield ability (X_6) was also studied. When a correction was made for the effect of X_6, the coefficients for X_{14} and X_{15} (variables highly correlated with X_6) changed somewhat, but the coefficients and t-values for precipitation variables, as well as R^2, changed very little. The coefficient for X_6 was not acceptable. This was probably due to the extremely large correlation (0.958622) between X_6 and X_{15}, and the small variation in X_6, making it impossible to isolate the effects of these variables.

Evidence that wheat yields were influenced by precipitation was detected in both counties. It was also detected that wheat yields were associated with the factors represented by time in Finney County. Further evidence, although less decisive, was detected for the percentage of wheat seeded on fallow in Barton County.

The results of studying production on a fixed technical unit (land, corrected for amount of wheat seeded on fallow) were remarkably similar to the results obtained from studying total production. The effects of the precipitation variables were generally important. Both dependent variables could be predicted at seeding time with a higher degree of precision for Finney County.

For both equations, the coefficients and t-values were larger for X_5 (rainfall close to harvest time) and lowest for X_{2t-1}, the period of rainfall most removed in time from harvest. Thus, there was evidence that a crop is more dependent upon recent moisture, and less dependent on (but by no means independent of) rainfall earlier in time. The variables for X_6, X_{15}, and X_{14}, or Y_9 and Y_6 were so highly correlated that meaningful coefficients were in most tests not obtained. It was not deemed too serious that the separate effects of fallow and yield ability could not be detected because their influence has been ascertained by experiments. Although these variables are highly correlated and their isolated effects thus difficult to measure, predictions of the dependent variables are still reliable, and effects of precipitation variables which were not correlated with each other or with these other independent variables, may be observed. Thus, the influence of precipitation on production, under farm conditions, may be examined, where two of the three measures used in this study would be known at seeding time.

Logarithmic Function. The results from the logarithmic functions derived to explain wheat yields were closely parallel to those obtained from the use of linear functions. Not only were the values of R^2 comparable, but the contribution of the respective variables was similar as detected by the two types of equations. The effects of the precipitation variables were again evident, and the order of importance (as measured by the size and significance of the coefficients) as before, was X_5, X_2, and X_{2t-1}. More acceptable coefficients were obtained by the logarithmic function for X_{2t-1} for Finney County, but time was less important for this county as determined by the logarithmic formulation. Again, X_5 explained more of the variation in the dependent variable for Barton County than for Finney County.

Because X_{15} was highly correlated with X_{14} and X_6, functions were derived with the effects of time excluded. The value for R^2 was not reduced appreciably when no correction was made for the effects due to this variable, nor were the coefficients and t-ratios for coefficients for other independent variables changed appreciably.

The logarithmic functions used to explain yields were considered more logical than the logarithmic functions used to explain total production. Although the values for R^2 were generally no higher, more acceptable coefficients were obtained, especially for the precipitation variables.

Grain Sorghum Yields

Linear Function. In the formulations derived to explain grain sorghum yields, a higher degree of fit was obtained for Barton County than for Finney County. Values for R^2 for Barton County were from nearly 56 to 67.54 percent, but were only 50.87 to 55.54 percent for Finney County.

In light of the hypothesis advanced, coefficients for the precipitation variables X_9, X_{10}, and X_2 were of the appropriate sign. Other things remaining equal, grain sorghum yields increased with increases in precipitation. The t-values for the coefficients of X_9 and X_{10} were significant beyond the one percent level for both counties. For Finney County, the t-value for X_2 was significant at the 5 percent level, but only at the 10 percent level for Barton County. The coefficients for these respective precipitation variables were quite similar among all formulations for both counties. This indicates that as precipitation increased by similar amounts in both counties, yield increased approximately the same for both counties. For these variables, the coefficients and t-values were highest for rainfall July 1 to

October 1 prior to harvest, the period when the crop makes most of its growth, and lowest for rainfall April 1 to October 1 a year earlier, which it is assumed, reflects subsoil moisture conditions.

The influence of acres fallowed the previous year (Y_6) was hypothesized to increase grain sorghum yields. However, a highly significant negative coefficient was obtained for Barton County and a nonsignificant positive coefficient was obtained for Finney County. Because of the high intercorrelation (0.655950 for Barton County and 0.902408 for Finney County) between Y_6 and X_{15}, the effects of changes in Y_6 and X_{15} may not be easily isolated. It is also possible that when more acreage was fallowed in Barton County, sorghums would be planted on poorer soil thus reducing the yield. In any case, the negative coefficient for fallow is not reasonable, and it can only be concluded that no evidence was detected that grain sorghum yields are increased following years of high fallow acreages. Experimental results have indicated that fallow increases grain sorghum yields in the areas of these counties. Therefore, these results suggest either that little sorghum is seeded on fallow or that the proportion of the total acreage seeded on fallow has changed but little over time.

It was detected that yields were influenced by the factors represented by the time variable in Barton County; however, the t-value for the coefficient for X_{15} in Finney County was not significant at the 50 percent level.

Two alternative formulations were derived for both counties. The first alternative was to drop the acreage fallowed variable (Y_6) because it was believed that little sorghum was planted on fallowed land and this was, in part, suggested by the results. The value of R^2 was lowered approximately 11 percent in Barton County and was unchanged for Finney County. The only coefficient changed appreciately was that for time. For this alternative, the coefficient is significant at the 10 percent level in Finney County, but is not significant at the 50 percent level for Barton County.

Another alternative function expresses grain sorghum yield as a linear function of the three precipitation variables. This was accomplished by dropping both Y_6 and X_{15} from the first formulation. For this formulation, the value of R^2 was decreased approximately 12 percent in Barton County and 5 percent in Finney County, but the values for the precipitation coefficients were changed only slightly.

The influence of precipitation on yields was detected for both counties in all of the formulations derived. Some influence associated with time was detected, but the influence was not consistent for all formulations.

Logarithmic Function. The particular linear functions used do not portray curvilinear relationships. The Cobb-Douglas function is linear in logarithms and, therefore, curvilinear in real numerical values.

Values for R^2 were 23.56 to 26 percent for Barton County and approximately 37 percent for Finney County, which were well below the values for R^2 for the linear function, indicating that a lower degree of fit was obtained by this function. The coefficients for precipitation variables were also lower for this function. For Barton County, the t-values for X_9 and X_{10} were significant at the 10 percent level, and for X_2 were significant at the 30 percent level. For Finney County, the t-value for X_9 was significant at the one percent level, for X_2 at the 20 percent level, and for X_{10} at the 40 percent level. Except for X_2 for Barton County, these coefficients were significant at the 5 percent level or higher for the linear functions.

The coefficients for acres fallowed (Y_6) were not acceptable. Because it is not believed that much sorghum was planted on fallowed land (including the variable in the function was an indirect means of testing this), Y_6 was not included in one of the formulations, and the results were approximately the same as those for the functions in which there was a correction for the effects of Y_6.

Evidence was detected, although it was considerably less decisive than in the formulations in linear form, that precipitation influenced grain sorghum yields.

The sum of exponents, which in a Cobb-Douglas function indicates returns to scale, is considerably greater than one for all formulations. This means that there was "increasing returns to scale" for precipitation, or that if all variables were to increase by one percent, yields would increase by more than one percent. For this rather low rainfall region, this may be an accurate description.

The results from the linear functions were clearly superior for the tests conducted in this study. It may be that a linear function, where yields change at a constant rate with respect to changes in a particular variable, may well describe the relations for the amount of precipitation that actually falls in this area. This type of relation undoubtedly would not hold in higher rainfall regions, however.

SUMMARY

This study was concerned with explaining the production of winter wheat and grain sorghum in two counties of Kansas, Barton and Finney. County data were available, furnished largely by the Federal-State Agricultural Statistician. It was believed that conditions within these counties were more homogeneous than for the broad areas studied by others. The study was of time series nature, and the period studied was 1917-53. Coefficients were estimated for a number of variables. For each equation, it was possible to relate a dependent variable as a function of independent variables. Therefore, single equation multiple regression was the appropriate method of analysis.

Linear functions were derived for all decision and productivity relations. Logarithmic production functions were also derived. The linear production functions were superior to the logarithmic functions for both counties, especially in explaining wheat production and grain sorghum yields. Not only was the degree of fit higher, but the coefficients were more acceptable, both statistically and logically.

The final supply of wheat and sorghum is determined by the amount of resources committed, and by the productivity of these resources. Hypotheses were stated for the decision relationships. These concerned the allocation of resources, with emphasis on land and soil moisture (as reflected by precipitation), to the production of the two commodities. It was hypothesized that the amount of resources committed to a specific crop was related to the stocks on hand at the decision-making time, and to the relation of their expected discounted marginal value productivity if used for this crop, versus the expected returns from alternative used (opportunity costs).

Hypotheses were also stated for resource productivity. To complete the study on supply response, it was necessary to analyze the forces behind the productivity of resources used to produce these crops. Since productivity influences the allocation of resources, the productivity equations mainfested marked similarities to the decision equations.

Due to a high intercorrelation between a number of the independent variables, effects due to some of the variables were not detected for certain formulations. Because the acreage fallowed was highly correlated with time, it was not possible to detect the influence of fallow in several of the equations.

For Finney County, moisture variables more completely explained resource commitment and productivity then they did in Barton County, although the effects for precipitation were clear for this county also. Moisture was a more crucial factor in Finney County, where average precipitation was considerably less.

The influence of price, although less decisive than the effects of moisture, was detected for some formulations of the wheat seeding and fallowing equations for Barton County, and for Finney County for the acreage of all sorghums and grain sorghum harvested. It was also found that price influenced the acreage of wheat harvested and abandoned in both counties.

There was evidence that continuous wheat, wheat after fallow, and sorghums were competing crops. The acreage of sorghum harvested was clearly a function of acres of wheat seeded and acres of wheat abandoned. Likewise, acreage of wheat seeded was related to the acreage of cropland (growing row crops excluded). Because of this interrelation, a study of either could be made only if an integrated study was formulated, where the influence of the production of each on the production of the other could be ascertained.

The influence of the variable time was apparent in many formulations. This was true even after a correction had been made for the influence of other variables. For most of the wheat production and wheat yield formulations, the dependent variable was associated with soil moisture as reflected by precipitation for prior periods. However, for the wheat seeding equation, no evidence was detected that farmers change their wheat acreage seeded in response to these precipitation variables. Thus, there is some indication that farmers may not be exercising as much strategy in the use of soil moisture as would be profitable.

For each county and each equation, the logically acceptable coefficients are listed for two probability levels (Table 3). For some equations, different formulations were tested. For these cases, these summary results are average for the formulations. There may be particular formulations for an equation where some coefficients are not significant at the level indicated.

Table 3. Logically acceptable coefficients, by equation and by county, two probability levels.

Equation and dependent variable	Barton County		Finney County	
	P .10	.30 P .10	P .10	.30 P .10
(1) Wheat seeding, Y_1	X_{12}, Y_7		X_{15}, X_{12}, Y_7	
(2) Acreage fallowed, Y_6	X_3	X_{15}	X_{15}, X_{11}, X_2	
(3) Wheat harvesting, Y_2	X_5, Y_1 or Y_6, and Y_9	X_2, X_3	X_2, X_5, Y_1 or Y_6, and Y_9	X_3
(4) Wheat abandonment, Y_7	X_5	X_2, X_3	X_2, X_5, Y_1 or Y_9	X_3, Y_6
(5) All sorghum harvested, X_{13}	Y_7, Y_1, X_{15}		X_9, Y_7, Y_1, X_{15}	X_8
(6) Grain sorghum harvested, Y_4	X_{18}, Y_7, X_{15}		X_9, Y_1, X_{15}	X_{18}, X_8, Y_7
(7) Wheat production, Y_8	X_2, X_{2t-1}, X_5	X_{15}	X_2, X_{15}, X_5	Y_9
(8) Wheat production, log, Y_8	X_{15}	X_2, X_{2t-1}, X_5	X_2, X_{15}, X_5	
(9) Wheat yields, Y_3	X_2, X_5	X_{2t-1}, X_{14}	X_2, X_{15}, X_5	
(10) Wheat yields, log, Y_3	X_2, X_5	X_{14}, X_{2t-1}	X_2, X_5	X_{2t-1}, X_{15}
(11) Grain sorghum yields, Y_5	X_9, X_{10}, X_2	X_{15}	X_9, X_{10}, X_2	X_{15}
(12) Grain sorghum yields, log, Y_5	X_9, X_{10}	X_2	X_9	X_2

For 30 degrees of freedom, the approximate number of degrees of freedom for most of the formulations, t-values are 1.697 for the 10 percent probability level and 1.055 for the 30 percent probability level.

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APPENDIX

Acceptable coefficients, both from the standpoint of logic and statistical probability, may not be obtained for a number of reasons. The variable may not be important. Certain important variables may be omitted. It may have been incorrectly measured. It may have been highly correlated with other independent variables. That was true for some variables used in this study, such as X_{15} and Y_6, but was not true for other variables, especially the precipitation variables. Because the success in detecting the separate effects of independent variables in multiple regression is highly related to the non-intercorrelation of these variables, matrices are presented, giving simple correlation coefficients for all variables used in this study.

A non-acceptable coefficient may be obtained because an inappropriate algebraic form was used. For all the production function equations, both linear and logarithmic formulations were tested.

A further explanation is lack of variation for a dependent variable. Table 4 shows coefficients of variation for all variables used. This measure of variation is independent of size of units because it corrects the variation for the mean. This measure is calculated by dividing s by the mean, where s is an unbiased estimate of the square root of the population variance, and where s^2 equals the adjusted sum of squares divided by the degrees of freedom.

Table 4. Coefficients of variation for variables used in supply response formulations.

Variable	Coefficient of variation		Variable	Coefficient of variation	
	Barton	Finney		Barton	Finney
X_2	27.42	36.51	X_{15}	31.43	31.43
X_3	44.01	43.91	X_{16}	6.76	17.59
X_5	39.22	61.37	Y_1	6.65	48.49
X_6	2.06	---	Y_2	19.49	68.37
X_8	27.64	27.64	Y_3	34.21	49.01
X_9	41.73	39.27	Y_4	66.34	52.48
X_{10}	36.76	40.13	Y_5	47.61	48.38
X_{11}	33.44	34.87	Y_6	105.46	97.94
X_{12}	16.25	56.03	Y_7	117.76	118.19
X_{13}	39.08	42.64	Y_8	42.23	102.88
X_{14}	114.29	103.01	Y_9	15.24	53.97

Table 5. Wheat seeding equation, 1917-53.[1]

		Dependent	Independent					
		Y_1	X_2	X_{15}	X_3	X_{12}	Y_7	Y_6
Barton County								
	Unit	(00) acres	Inches x 10	Years	Dol./bu. x 100	(00) acres	(00) acres	(00) acres
	Mean	4204.054054	164.432432	35.000000	130.135135	2940.169189	370.675676	233.783784
Function (a)								
R^2 42.66	b		-.329327	16.616104	-.404676	.058526	.092166	-.974929
a 2606.410376	t		0.42	2.79	0.52	0.33	0.47	2.98
Function (b)								
R^2 25.69	b		-.328162	2.250235	.453445	.503222	.415422	
a 1412.178693	t		0.38	0.53	0.56	2.90	2.27	
Function (c)								
R^2 13.36	b		-.106403	.567667	.634318	.177345		
a 2518.750356	t		0.12	0.13	0.75	1.73		
Finney County								
	Unit	(000) acres	Inches x 10	Years	Dol./bu. x 100	(000) acres	(000) acres	(000) acres
	Mean	194.234200	139.783800	35.000000	129.973000	139.594600	63.061100	57.054100
Function (a)								
R^2 66.91	b		-.020048	7.092871	-.139916	.602697	.782605	-1.048845
a -106.679520	t		0.14	2.68	1.08	2.94	5.99	2.81

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[1] Tables 5-5r refer to means, regression coefficients, units of measure, t values, coefficients of multiple determination, and y intercepts, for Barton and Finney counties.

Table 5a. Wheat seeding equation, 1917-30.

		Dependent	Independent				
		Y_1	X_2	X_{15}	X_3	X_{12}	Y_7
				Barton County			
	Unit	(00) acres	In. x 10	Years	Dol/bu. x 100	(00) acres	(00) acres
	Mean	3136.428571	192.928571	23.500000	142.214286	2924.428571	450.071428
Function (a)							
R^2 66.54	b		.392200	36.336125	.061985	-.014207	.007405
a 2233.672444	t		0.34	1.66	0.07	0.04	0.03
Function (b)							
R^2 66.54	b		.367332	36.745640	.093935	-.024219	
a 2255.645674	t		0.36	2.35	0.10	0.25	

Table 5b. Wheat seeding equation, 1931-40.

		Dependent	Independent					
		Y_1	X_2	X_{15}	X_3	X_{12}	Y_7	Y_6
				Barton County				
	Unit	(00) acres	Inches x 10	Years	Dol./bu. x 100	(00) acres	(00) acres	(00) acres
	Mean	3132.000000	160.200000	35.500000	69.600000	2525.000000	459.100000	348.100000
Function (a)								
R^2 93.52	b		-2.627787	-137.996677	9.711878	1.242757	1.761089	.678430
a 3220.440123	t		2.19	2.70	4.94	3.78	3.98	0.98
Function (b)								
R^2 91.46	b		-2.267752	-91.067215	9.676759	.983268	1.450231	
a 2611.138705	t		2.00	5.22	4.95	5.08	4.75	
Function (c)								
R^2 43.24	b		.435633	-45.662593	6.453548	.143051		
a 3829.947379	t		0.19	1.36	1.53	0.79		

Table 5c. Wheat seeding equation, 1941-53.

		Dependent	Independent					
		Y_1	X_2	X_{15}	X_3	X_{12}	Y_7	Y_6
				Barton County				
	Unit	(00) acres	Inches x 10	Years	Dol./bu. x 100	(00) acres	(00) acres	(00) acres
	Mean	3101.538461	193.923077	47.000000	163.692308	3045.769231	217.153846	397.615385
Function (a)								
R^2 89.80	b		.295598	25.460081	2.271816	-1.663188	-.828858	-3.086677
a 7948.702537	t		0.34	0.72	0.78	3.64	1.98	4.56
Function (b)								
R^2 54.48	b		-.682396	40.561504	1.799176	.173292	.514478	
a 393.437991	t		0.41	0.59	0.32	0.41	0.89	
Function (c)								
R^2 49.35	b		-.685392	60.960725	.718919	-.035311		
a 359.164804	t		0.42	0.95	0.13	0.10		

Table 5d. Acreage fallowed equation, 1931-53.

		Dependent	Independent					
		Y_6	X_{15}	X_{11}	X_3	X_2	Y_2	X_{18}
				Barton County				
	Unit	(00) acres	Years	(00) acres	Dol./bu. x 100	Inches x 10	(00) acres	(00) acres
	Mean	388.000000	42.000000	244.782609	122.782609	179.260870	2796.347828	3382.956522
Function (a)								
R^2 49.17	b		19.851373	-.464951	-2.365766	-.141725	.213037	-.448694
a 914.521320	t		1.31	0.69	1.38	0.21	0.93	1.86
Function (b)								
R^2 29.65	b		34.187658	-.533609	-3.864471	-.546028		
a -344.892364	t		2.24	0.98	2.42	0.75		
				Finney County				
	Unit	(000) acres	Years	(000) acres	Dol./bu. x 100	Inches x 10	(000) acres	(000) acres
	Mean	100.434783	42.000000	66.608698	122.521739	133.000000	166.869565	261.521739
Function (a)								
R^2 85.35	b		6.438816	.707203	-.073411	-.468454	.090380	-.085343
a -138.565116	t		3.75	1.85	0.36	3.88	0.38	0.33
Function (b)								
R^2 85.23	b		6.536632	.579459	-.075127	-.448617		
a -143.830134	t		4.25	4.18	0.47	4.79		

Table 5e. Acreage fallowed equation, 1931-53.

		Dependent	Independent				
		Y_6	X_{15}	X_{18}	X_2	Y_2	X_{11}
				Barton County			
	Unit	(00) acres	Years	(00) acres	In. x 10	(00) acres	(00) acres
	Mean	388.000000	42.000000	3382.956522	179.260870	2796.347826	244.782609
Function (a)							
R^2 43.08	b		1.847760	-.448025	.117111	.135282	-.754065
a 1611.338268	t		0.23	1.81	0.17	0.59	1.14
Function (b)							
R^2 38.72	b		-4.355898	-.591605	.142058	.298802	
a 1711.303789	t		0.76	2.76	0.21	1.67	
Function (c)							
R^2 29.23	b		-1.337953	-.270850	-.077547		
a 1374.369923	t		0.23	2.73	0.11		
				Finney County			
	Unit	(000) acres	Years	(000) acres	In. x 10	(000) acres	(000) acres
	Mean	100.434783	42.000000	261.521739	133.000000	166.869565	66.608696
Function (a)							
R^2 85.23	b		5.883469	-.110241	-.454241	.093366	.685867
a -118.691094	t		7.68	0.46	4.09	0.40	1.86

Table 5f. Wheat harvesting equation, 1917-53.

		Dependent	Independent			
		Y_2	X_2	X_5	X_3	Y_1
				Barton County		
	Unit	(00) acres	In. x 10	In. x 10	Dol./bu. x 100	(00) acres
	Mean	2743.108108	164.432432	63.027027	132.675676	3122.972973
Function (a)						
R^2 46.34	b		1.382526	7.358465	1.082940	1.016055
a -1292.457721	t		1.00	2.61	0.91	4.09
				Finney County		
	Unit	(000) acres	In. x 10	In. x 10	Dol./bu. x 100	(000) acres
	Mean	128.702700	139.783800	48.054100	132.513500	194.243200
Function (a)						
R^2 59.77	b		.452560	.669701	.239099	.647575
a -124.210621	t		2.23	1.96	1.37	6.07

Table 5g. Wheat harvesting equation, 1917-53.

		Dependent	Independent				
		Y_2	X_2	X_5	X_3	Y_6	Y_9
				Barton County			
	Unit	(00) acres	In. x 10	In. x 10	Dol/bu. x 100	(00) acres	(00) acres
	Mean	2743.108108	184.432432	63.027027	132.675676	233.783784	2889.189189
Function (a)							
R^2 49.90	b		1.464794	8.075076	1.197178	1.626899	1.172336
a 1962.281321	t		1.08	2.87	1.02	3.40	4.42
Function (b)							
R^2 18.22	b		1.567979	7.434251	1.364791		
a 1804.288803	t		0.93	2.17	0.94		
				Finney County			
	Unit	(000) acres	In. x 10	In. x 10	Dol/bu. x 100	(000) acres	(000) acres
	Mean	128.702700	139.783800	48.054100	132.513500	57.054100	137.216200
Function (a)							
R^2 59.84	b		.455088	.688694	.219684	.681660	.625479
a -121.834346	t		2.21	1.92	1.10	3.53	4.19

Table 5h. Wheat abandonment equation, 1917-53.

		Dependent	Independent			
		Y_7	X_2	X_5	X_3	Y_1
			Barton County			
	Unit	(00) acres	In. x 10	In. x 10	Dol./bu. x 100	(00) acres
	Mean	379.864865	184.432432	83.027027	132.675676	3122.972973
Function (a)						
R^2 23.36	b		-1.382530	-7.358468	-1.082934	-.018061
a 1292.489651	t		1.00	2.81	0.91	0.08
			Finney County			
	Unit	(000) acres	In. x 10	In. x 10	Dol/bu. x 100	(000) acres
	Mean	65.540500	139.783800	48.054100	132.513500	194.243200
Function (a)						
R^2 48.08	b		-.452562	-.669699	-.239098	.352425
a 124.210872	t		2.23	1.96	1.37	3.31

Table 51. Wheat abandonment equation, 1917-53.

		Dependent	Independent				
		Y_7	X_2	X_5	X_3	Y_6	Y_9
				Barton County			
	Unit	(00) acres	In. x 10	In. x 10	Dol/bu. x 100	(00) acres	(00) acres
	Mean	379.864865	184.432432	63.027027	132.675676	233.783784	2889.189189
Function (a)							
R^2 28.45	b		-1.465360	-8.075115	-1.197183	-.626906	-.172337
a 1962.392161	t		1.08	2.87	1.02	1.31	0.65
Function (b)							
R^2 23.35	b		-1.386035	-7.359662	-1.087395		
a 1243.623191	t		1.02	2.65	0.93		
				Finney County			
	Unit	(000) acres	In. x 10	In. x 10	Dol/bu. x 100	(000) acres	(000) acres
	Mean	65.540500	139.783800	48.054100	132.513500	57.054100	137.216200
Function (a)							
R^2 48.15	b		-.455129	-.688417	-.219248	.318700	.373892
a 121.807559	t		2.21	1.92	1.10	1.65	2.50

Table 5j. All sorghum harvested equation, 1917-53.

		Dependent	Independent					
		X_{13}	X_{18}	X_8	X_9	Y_7	Y_1	X_{15}
				Barton County				
	Unit	(00) acres	(00) acres	Percent	Inches x 10	(00) acres	(00) acres	Years
	Mean	220.324324	3469.594595	69.189189	82.135135	379.864865	3122.972973	35.000000
Function (a)								
R^2 57.24	b		.024838	.322833	.179250	.081090	-.070567	5.968285
a 77.772419	t		0.70	0.56	0.59	3.19	1.73	5.76
				Finney County				
	Unit	(000) acres	(000) acres	Percent	Inches x 10	(000) acres	(000) acres	Years
	Mean	60.945900	215.783800	69.189200	64.729700	65.540500	194.243200	35.000000
Function (a)								
R^2 76.65	b		-.034962	.182469	.344070	.296405	-.114201	1.455189
a -14.581538	t		0.49	1.49	3.58	7.40	1.92	3.53
Function (b)								
R^2 67.28	b		-.094597	.129786	.354258	.288794	-.070279	
a 44.171111	t		1.32	0.90	3.12	6.10	1.02	

Table 5k. Grain sorghum harvested equation, 1917-53.

		Dependent	Independent					
		Y_4	X_{18}	X_8	X_9	Y_7	Y_1	X_{15}
				Barton County				
	Unit	(00) acres	(00) acres	Percent	Inches x 10	(00) acres	(00) acres	Years
	Mean	89.945946	3469.594595	69.189189	82.135135	379.864865	3122.972973	35.000000
Function (a)								
R^2 41.85	b		.05331	.011663	.327840	.066198	-.030903	2.842780
a -158.222662	t		1.87	0.25	1.34	3.23	0.94	3.39
				Finney County				
	Unit	(000) acres	(000) acres	Percent	Inches x 10	(000) acres	(000) acres	Years
	Mean	37.729700	215.783800	69.189200	64.729700	65.540500	194.243200	35.000000
Function (a)								
R^2 37.93	b		.008125	.187769	.303953	.078673	-.125154	1.243809
a -21.069267	t		0.09	1.23	2.55	1.58	1.69	2.42
Function (b)								
R^2 26.14	b		.118868	.142737	.312660	.072172	-.087616	
a -5.745712	t		1.45	0.87	2.40	1.33	1.11	

Table 51. Wheat production equation (linear), 1917-53.

		Dependent	Independent						
		Y_8	X_2	Y_9	Y_6	X_{2t-1}	X_{15}	X_5	X_6
				Barton County					
	Unit	(00) bushels	Inches x 10	(00) acres	(00) acres	Inches x 10	Years	Inches x 10	Percent
	Mean	36955.875676	184.432432	2889.189189	233.783784	184.945946	35.000000	83.027027	93.675676
Function (a)									
R^2 54.43	b		84.018306	-.318083	-4.489218	83.184285	817.277687	366.465937	-2327.143433
a 176229.722432	t		2.11	0.03	0.21	1.95	0.83	3.95	0.47
Function (b)									
R^2 54.08	b		82.139395	-1.414380	-2.123303	87.990556	372.500468	349.088051	
a -24923.592440	t		2.10	0.16	0.10	2.15	1.26	4.37	
Function (c)									
R^2 24.88	b		101.328429	-2.938971	-8.793971	92.511517	334.405745		
a .751433	t		2.07	0.26	0.34	1.80	0.90		
				Finney County					
	Unit	(000) bushels	Inches x 10	(000) acres	(000) acres	Inches x 10	Years	Inches x 10	
	Mean	1854.884900	139.783800	137.216200	57.054100	143.783800	35.000000	48.054100	
Function (a)									
R^2 62.07	b		10.556154	4.542277	-9.741328	4.080254	137.100687	20.667916	
a -6087.979400	t		2.32	1.11	0.78	0.87	2.07	2.67	
Function (b)									
R^2 53.03	b		12.293107	4.583880	-15.951834	1.885012	183.519449		
a -5570.972300	t		2.49	1.02	1.19	0.37	2.28		

Table 5m. Wheat production equation (logarithmic), 1917-53.

		Dependent	Independent						
		Y_8	X_2	Y_9	Y_6	X_{2t-1}	X_{15}	X_5	X_6
Barton County									
	Unit	Log (00) bu.	Log In. x 10	Log (00) acres	Log (00)acres	Log In. x 10	Years	Log In. x 10	Percent
	Mean[1]	33074.500000	177.564167	2849.960000	32.077077	178.233333	35.000000	58.118500	93.675675
Function (a)									
R^2 59.05	b		.346849	.480068	-.184785	.043688	.075554	.029085	-.299030
a 27.576875[2]	t		1.33	0.87	2.38	0.16	4.43	0.16	4.20
Function (b)									
R^2 34.12	b		.448319	-.225454	-.050864	.397597	.009859	.330929	
a 2.543126	t		1.38	0.34	0.58	1.25	1.17	1.55	
Function (c)									
R^2 28.87	b		.343376	-.581166	-.118603	.354433	.015378		
a 4.597545	t		1.06	0.93	1.52	1.09	1.97		
Finney County									
	Unit	Log (000)acres	Log In. x 10	Log (000)acres	Log (000)acres	Log In. x 10	Years	Log In. x 10	
	Mean	9377.220000	130.586364	60.028857	54.427620	134.521515	35.000000	40.966455	
Function (a)									
R^2 73.20	b		.663729	.151589	-.293798	-.130034	.068761	.880792	
a -.741945	t		1.79	0.41	2.79	0.34	5.13	3.45	
Function (b)									
R^2 62.58	b		.937643	-.234199	-.387774	-.390106	.079198		
a 1.136300	t		2.22	0.57	3.28	0.91	5.22		

1. Means for Y_8, X_2, Y_9, Y_6, X_{2t-1}, and X_5 are geometric means.

2. Figures presented for a's are logs. The true a's would be the antilogs of the respective logs.

Table 5n. Wheat yield equation (linear), 1917-53.

		Dependent	Independent					
		Y_3	X_2	X_{14}	X_{2t-1}	X_{15}	X_5	X_6
				Barton County				
	Unit	Bushels x 10	Inches x 10	Percent x 10	Inches x 10	Years	Inches x 10	Percent
	Mean	132.108108	184.432432	78.945946	184.945946	35.000000	63.027027	93.675676
Function (a)								
R^2 47.24	b		.255728	.019786	.198357	2.258252	.892908	-11.509378
a 938.844676	t		2.11	0.81	1.55	0.76	3.44	0.78
Function (b)								
R^2 46.17	b		.243105	.148756	.218311	.017871	.953078	
a -25.543033	t		2.03	1.74	1.75	0.02	3.88	
Function (c)								
R^2 20.09	b		.300459	.132063	.235290	-.230354		
a 30.814226	t		2.11	1.29	1.58	0.27		
				Finney County				
	Unit	Bushels x 10	Inches x 10	Percent x 10	Inches x 10	Years	Inches x 10	
	Mean	119.027000	139.783800	238.486500	143.783800	35.000000	48.054100	
Function (a)								
R^2 43.81	b		.484480	-.066647	.054129	2.729080	.535718	
a -61.845200	t		3.00	1.07	0.34	2.00	1.90	
Function (b)								
R^2 37.24	b		.525141	-.092933	-.001252	3.160616		
a -42.657500	t		3.15	1.47	0.01	2.25		

Table 5c. Wheat yield equation (logarithmic), 1917-53.

		Dependent	Independent					
		Y_3	X_2	X_{14}	X_{2t-1}	X_{15}	X_5	X_6
				Barton County				
	Unit	Log bu. x 10	Log in. x 10	Percent x 10	Log in. x 10	Years	Log in. x 10	Percent
	Mean[1]	124.180857	177.564167	78.945946	178.233333	35.000000	58.118500	93.675675
Function (a)								
R^2 46.53	b		.403344	.026127	.224819	.012842	.406282	-.063534
a 3.403413[2]	t		2.31	0.07	1.25	1.27	3.39	1.25
Function (b)								
R^2 43.74	b		.377770	.324607	.245131	.000536	.441056	
a -25.730802	t		2.16	1.09	1.35	0.22	3.75	
Function (c)								
R^2 18.17	b		.421690	.289304	.345775	-.000079		
a -22.469426	t		2.03	0.82	1.63	0.03		
				Finney County				
	Unit	Log bu. x 10	Log in. x 10	Percent x 10	Log in. x 10	Years	Log in. x 10	
	Mean	103.810714	130.586364	238.486486	134.521515	35.000000	40.966455	
Function (a)								
R^2 43.30	b		.574061	-.000110	.231033	.007671	.319182	
a -.447139	t		2.69	0.41	1.12	1.32	2.30	
Function (b)								
R^2 33.65	b		.681002	-.000183	.150043	.008989		
a -.015066	t		3.07	0.65	0.69	1.46		

1. Means of Y_3, X_2, X_{2t-1}, and X_5 are geometric means.

2. Figures presented for a's are logs. The true a's would be antilogs of the respective logs.

Table 5p. Wheat yield equation (logarithmic), 1917-53.

		Dependent	Independent				
		Y_3	X_2	X_{14}	X_{2t-1}	X_5	X_6
				Barton County			
	Unit	Log bu. x 10	Log in. x 10	Percent x 10	Log in. x 10	Log in. x 10	Percent
	Mean[1]	124.180857	177.564167	78.945946	178.233333	58.118500	93.675675
Function (a)							
R^2 43.67	b		.380283	.373851	.253088	.438047	-.001191
a -29.506344[2]	t		2.17	1.41	1.40	3.71	0.10
Function (b)							
R^2 43.66	b		.379192	.362936	.250957	.439409	
a -25.909315	t		2.20	1.54	1.42	3.80	
Function (c)							
R^2 18.17	b		.421504	.283593	.344961		
a -22.019081	t		2.06	1.02	1.66		

1. Means of Y_3, X_2, X_{2t-1}, and X_5 are geometric means.

2. Figures presented for a's are logs. The true a's would be the antilog of the respective logs.

Table 5q. Grain sorghum yield equation (linear), 1917-53.

		Dependent	Independent				
		Y_5	X_9	X_{10}	X_2	X_{15}	Y_6
				Barton County			
	Unit	Bu. x 10	In. x 10	In. x 10	In. x 10	Years	(00) acres
	Mean	174.675676	82.135135	129.864865	184.432432	35.000000	233.783784
Function (a)							
R^2 67.54	b		1.387797	.748775	.244769	2.685216	-.153453
a -139.801783	t		5.54	4.17	1.43	2.53	3.30
Function (b)							
R^2 56.15	b		1.431445	.718171	.323897	.364842	
a -108.668107	t		5.00	3.50	1.67	0.40	
Function (c)							
R^2 55.93	b		1.430665	.712638	.328001		
a -95.872955	t		5.06	3.52	1.71		
				Finney County			
	Unit	Bu. x 10	In. x 10	In. x 10	In. x 10	Years	(000) acres
	Mean	167.000000	64.729730	93.756757	139.783784	35.000000	57.054054
Function (a)							
R^2 55.54	b		1.489030	.770246	.409497	.558612	.214226
a -90.965280	t		3.61	2.78	2.12	0.27	0.52
Function (b)							
R^2 55.16	b		1.460094	.769427	.391605	1.557511	
a -108.903572	t		3.61	2.81	2.08	1.75	
Function (c)							
R^2 50.87	b		1.413972	.734686	.386636		
a -47.453248	t		3.40	2.61	2.00		

Table 5r. Grain sorghum yield equation (logarithmic), 1917-53.

		Dependent	Independent			
		Y_5	X_9	X_{10}	X_2	Y_6
				Barton County		
	Unit	Log Bu. x 10	Log In. x 10	Log In. x 10	Log In. x 10	Log (00) acres
	Mean[1]	126.647143	76.030833	121.338889	177.564187	32.077077
Function (a)						
R^2 28.03	b		.895896	.924677	.668758	-.070978
a .001249	t		1.79	1.94	0.95	1.04
Function (b)						
R^2 23.56	b		.979220	1.000993	.793805	
a .000247	t		1.98	2.13	1.14	
				Finney County		
	Unit	Log Bu. x 10	Log In. x 10	Log In. x 10	Log In. x 10	Log (00) acres
	Mean	121.057778	60.028857	88.824000	130.586364	54.42762
Function (a)						
R^2 37.42	b		1.393815	.416408	.712238	-.026127
a .002183	t		2.85	0.85	1.52	0.47
Function (b)						
R^2 38.99	b		1.437041	.445603	.744895	
a .001223	t		3.03	0.93	1.63	

[1] All means are geometric means.

Table 6. Wheat seeding equation, 1917-53.[1]

Variable category	X_2	X_{15}	X_3	X_{12}	Y_7	Y_6	Y_1
				Barton County			
X_2	1.000000	.051509	.120174	.133103	-.049575	-.074644	.037796
X_{15}		1.000000	.204074	.236265	-.282177	.656021	.119016
X_3			1.000000	.280695	-.192226	-.186115	.216910
X_{12}				1.000000	-.839458	-.263269	.341928
Y_7					1.000000	-.026776	-.098380
Y_6						1.000000	-.397095
Y_1							1.000000
				Finney County			
X_2	1.000000	-.024541	.212594	-.083670	-.187214	-.102017	-.151025
X_{15}		1.000000	.200557	.770450	.185081	.902409	.764734
X_3			1.000000	.212060	-.322775	.207980	-.149869
X_{12}				1.000000	-.290066	.517906	.630065
Y_7					1.000000	.382750	.436722
Y_6						1.000000	.619103
Y_1							1.000000

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[1] Tables 6-6k refer to correlation matrix, for Barton and Finney counties.

Table 6a. Wheat seeding equation by periods.

Variable category	X_2	X_{15}	X_3	X_{12}	Y_7	Y_6	Y_1
				Barton County (1917-1930)			
X_2	1.000000	.509708	-.029700	.209396	-.103890		.486988
X_{15}		1.000000	-.384217	.813792	-.422451		.809874
X_3			1.000000	.057021	-.071495		-.297719
X_{12}				1.000000	-.944586		.451484
Y_7					1.000000		-.288837
Y_1							1.000000
				Barton County (1931-1940)			
X_2	1.000000	-.145945	-.319080	.277849	-.00158	-.285640	.030647
X_{15}		1.000000	.481662	-.191927	.340461	.874869	-.297836
X_3			1.000000	-.135349	.018709	.533345	.297882
X_{12}				1.000000	-.858770	-.454333	.320127
Y_7					1.000000	.399399	-.152125
Y_8						1.000000	-.429618
Y_1							1.000000
				Barton County (1941-1953)			
X_2	1.000000	.014964	-.104915	-.138728	.151887	.168087	-.106845
X_{15}		1.000000	.915982	.572512	-.143418	-.615561	.691778
X_3			1.000000	.682074	-.313762	-.654328	.856819
X_{12}				1.000000	-.611446	-.843901	.403819
Y_7					1.000000	.206215	.050516
Y_6						1.000000	-.726531
Y_1							1.000000

Table 6b. Acreage fallowed equation, 1931-53.

Variable category	X_{15}	X_{11}	X_3	X_2	Y_2	X_{18}	Y_6
				Barton County			
X_{15}	1.000000	.500363	.919814	.248939	.221250	.107804	-.109682
X_{11}		1.000000	.476583	.193035	-.289478	-.134709	-.255482
X_3			1.000000	.142023	.370648	.270278	-.284463
X_2				1.000000	.026039	.088137	-.080757
Y_2					1.000000	.889076	-.349871
X_{18}						1.000000	-.537735
Y_6							1.000000
				Finney County			
X_{15}	1.000000	.047807	.919214	.357517	.438944	.532413	.773830
X_{11}		1.000000	.059513	.312354	-.870973	-.341515	.288558
X_3			1.000000	.264635	.470230	.619361	.732528
X_2				1.000000	.170064	.287991	-.033250
Y_2					1.000000	.889294	.055364
X_{18}						1.000000	.212070
Y_6							1.000000

Table 6c. Wheat harvesting and abandonment equations, 1917-53.

Variable category	X_2	X_5	X_3	Y_1	Y_7	Y_2
			Barton County			
X_2	1.000000	.118016	.069323	.037796	-.214448	.199218
X_5		1.000000	.046252	.013168	-.431714	.368138
X_3			1.000000	.060514	-.171608	.175255
Y_1				1.000000	-.029856	.548106
Y_7					1.000000	
Y_2						1.000000
			Finney County			
X_2	1.000000	.196223	.201776	-.151025	-.449129	.233721
X_5		1.000000	.089456	.024337	-.319129	.306969
X_3			1.000000	-.117671	-.313009	.149596
Y_1				1.000000	.488444	.640298
Y_7					1.000000	
Y_2						1.000000

Table 6d. Wheat harvesting and abandonment equations, 1917-53.

Variable category	X_2	X_5	X_3	Y_6	Y_9	Y_7	Y_2
				Barton County			
X_2	1.000000	.118016	.069323	-.074640	.065820	-.214448	.199218
X_5		1.000000	.046252	-.170339	.103774	-.431714	.368138
X_3			1.000000	-.093012	.090544	-.171608	.175255
Y_6				1.000000	-.812386	-.104842	-.119991
Y_9					1.000000	.039753	.415450
Y_7						1.000000	
Y_2							1.000000
				Finney County			
X_2	1.000000	.196223	.201776	-.102017	-.115197	-.449129	.233721
X_5		1.000000	.089456	-.138026	.135092	-.319129	.306969
X_3			1.000000	.267054	-.351811	-.313009	.149596
Y_6				1.000000	.032433	.264284	.429961
Y_9					1.000000	.421975	.490081
Y_7						1.000000	
Y_2							1.000000

Table 6e. All sorghum and grain sorghum harvested equations, 1917-53.

Variable category	X_{18}	X_8	X_9	Y_7	Y_1	X_{15}	X_{13}	Y_4
				Barton County				
X_{18}	1.000000	-.091789	.074854	-.010335	.375708	-.213085	-.156224	.136832
X_8		1.000000	-.133137	.342842	-.071940	-.074205	.159210	.127736
X_9			1.000000	-.011689	.020592	-.000674	.058724	.196277
Y_7				1.000000	-.029856	-.267557	.250323	.370262
Y_1					1.000000	.119008	-.120359	.013959
X_{15}						1.000000	.584602	.299776
X_{13}							1.000000	
Y_4								1.000000
				Finney County				
X_{18}	1.000000	-.015908	-.089388	.146538	.821587	.852170	.168705	.129780
X_8		1.000000	-.110530	.237181	.042361	-.074211	.246774	.136343
X_9			1.000000	-.239015	-.279600	-.098335	.175940	.393159
Y_7				1.000000	.488444	.165781	.718128	.084498
Y_1					1.000000	.764734	.306555	.000038
X_{15}						1.000000	.303484	.251181
X_{13}							1.000000	
Y_4								1.000000

Table 6f. Wheat production equation (linear), 1917-53.

Variable category	X_2	Y_9	Y_6	X_{2t-1}	X_{15}	X_5	X_6	Y_8
				Barton County				
X_2	1.000000	.065820	-.074640	-.041312	.051506	.118016	.067147	.332934
Y_9		1.000000	-.612386	.204494	-.291788	.103774	-.116626	.044584
Y_6			1.000000	-.121462	.655950	-.170339	.502783	.020016
X_{2t-1}				1.000000	.143416	.021977	.135508	.316396
X_{15}					1.000000	-.140562	.958622	.224490
X_5						1.000000	.165556	.555787
X_6							1.000000	.182040
Y_8								1.000000
				Finney County				
X_2	1.000000	-.115197	-.102017	-.026763	-.024541	.196223		.331774
Y_9		1.000000	.032433	-.164619	.291512	.135092		.386166
Y_6			1.000000	-.120768	.902409	-.138026		.336027
X_{2t-1}				1.000000	-.035758	-.139858		.035006
X_{15}					1.000000	-.040722		.547768
X_5						1.000000		.390981
Y_6								1.000000

Table 6g. Wheat production equation (logarithmic), 1917-53.

Variable category	X_2	Y_9	Y_6	X_{2t-1}	X_{15}	X_5	X_6	Y_8
				Barton County				
X_2	1.000000	-.001785	-.190405	-.065659	-.005288	.058184	.027217	.294539
Y_9		1.000000	-.552369	.150954	-.285662	.042688	-.110165	-.009174
Y_6			1.000000	-.138886	.842681	-.288981	.733184	-.001961
X_{2t-1}				1.000000	.085273	.139615	.073602	.300171
X_{15}					1.000000	-.091749	.958638	.240620
X_5						1.000000	.132565	.348121
X_6							1.000000	.134490
Y_8								1.000000
				Finney County				
X_2	1.000000	.123734	-.187192	.045866	-.037865	.260708		.369667
X_9		1.000000	-.267841	.156696	-.113715	-.202493		.038876
Y_6			1.000000	-.196896	.886965	-.090922		.304419
X_{2t-1}				1.000000	-.029852	-.127692		.036917
X_{15}					1.000000	-.010837		.581320
X_5						1.000000		.458172
Y_8								1.000000

Table 6h. Wheat yield equation (linear), 1917-53.

Variable category	X_2	X_{14}	X_{2t-1}	X_{15}	X_5	X_6	Y_3
			Barton County				
X_2	1.000000	-.035524	-.041312	.051506	.118016	.087147	.313241
X_{14}		1.000000	-.114772	.594665	-.140275	.431372	.189013
X_{2t-1}			1.000000	.143416	.021977	.135508	.208597
X_{15}				1.000000	-.140562	.958622	.156327
X_5					1.000000	-.185556	.516475
X_6						1.000000	.070164
Y_3							1.000000
			Finney County				
X_2	1.000000	-.163833	-.028763	-.024541	.196223		.509154
X_{14}		1.000000	-.134831	.830911	-.160219		.020829
X_{2t-1}			1.000000	-.035758	-.139858		.017478
X_{15}				1.000000	-.040722		.250057
X_5					1.000000		.371683
Y_3							1.000000

Table 61. Wheat yield equation (logarithmic), 1917-53.

Variable category	X_2	X_{14}	X_{2t-1}	X_{15}	X_5	X_6	Y_3
			Barton County				
X_2	1.000000	-.040937	-.065659	-.005238	.058184	.027217	.302084
X_{14}		1.000000	-.046354	.594701	-.096593	.431354	.134910
X_{2t-1}			1.000000	.085273	.139615	.073602	.234238
X_{15}				1.000000	-.091749	.958638	.112725
X_5					1.000000	-.132565	.536943
X_6						1.000000	.031233
Y_3							1.000000
			Finney County				
X_2	1.000000	-.220631	.045866	-.037865	.260708		.501424
X_{14}		1.000000	-.165384	.830911	-.097307		.026915
X_{2t-1}			1.000000	-.029852	-.127692		.143293
X_{15}				1.000000	-.010837		.225911
X_5					1.000000		.418056
Y_3							1.000000

Table 6j. Grain sorghum yield equation (linear), 1917-53.

Variable category	X_9	X_{10}	X_2	X_{15}	Y_6	Y_5
			Barton County			
X_9	1.000000	-.024283	.084738	-.000674	-.049886	.594009
X_{10}		1.000000	.006917	-.066380	-.005225	.394484
X_2			1.000000	.051506	-.074640	.251162
X_{15}				1.000000	.655950	.029742
Y_6					1.000000	-.266594
Y_5						1.000000
			Finney County			
X_9	1.000000	.360053	.059036	-.098335	-.154800	.582473
X_{10}		1.000000	.069566	-.103610	-.122647	.519303
X_2			1.000000	-.024541	-.102017	.294280
X_{15}				1.000000	.902408	.120322
Y_6					1.000000	.074026
Y_5						1.000000

Table 6k. Grain sorghum yield equation (logarithmic), 1917-53.

Variable category	X_9	X_{10}	X_2	Y_6	Y_5
Barton County					
X_9	1.000000	-.047429	.209610	-.188319	.329782
X_{10}		1.000000	-.087331	-.128454	.295165
X_2			1.000000	-.190261	.213775
Y_6				1.000000	-.284464
Y_5					1.000000
Finney County					
X_9	1.000000	.402261	.123734	-.267841	.543510
X_{10}		1.000000	.150765	-.232878	.359952
X_2			1.000000	-.187192	.306173
Y_6				1.000000	-.260661
Y_5					1.000000

FARM DECISION AND RESOURCE PRODUCTIVITY RELATIONS, WHEAT AND SORGHUM, CENTRAL AND WESTERN KANSAS, 1917-53

by

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This study was concerned with explaining the production of winter wheat and grain sorghum in two counties of Kansas, Barton and Finney. County data were available, furnished largely by the Federal-State Agricultural Statistician. It was believed that conditions within these counties were more homogeneous than for the broad areas studied by others. The study was of time series nature, and the period studied was 1917-53. Coefficients were estimated for a number of variables. For each equation, it was possible to relate a dependent variable as a function of independent variables. Therefore, single equation multiple regression was the appropriate method of analysis.

Linear functions were derived for all decision and productivity relations. Logarithmic production functions were also derived. The linear production functions were superior to the logarithmic functions for both counties, especially in explaining wheat production and grain sorghum yields. Not only was the degree of fit higher but the coefficients were more acceptable, both statistically and logically.

The final supply of wheat and sorghum is determined by the amount of resources committed, and by the productivity of these resources. Hypotheses were stated for the decision relationships. These concerned the allocation of resources, with emphasis on land and soil moisture (as reflected by precipitation), to the production of the two commodities. It was hypothesized that the amount of resources committed to a specific crop was related to the stocks on hand at the decision-making time, and to the relation of their expected discounted marginal value productivity if used for this crop, versus the expected returns from alternative uses (opportunity costs).

Hypotheses were also stated for resource productivity. To complete the study on supply response, it was necessary to analyze the forces behind the productivity of resources used to produce these crops. Since productivity influences the allocation of resources, the productivity equations manifested marked similarities to the decision equations.

Due to a high intercorrelation between a number of the independent variables, effects due to some of the variables were not detected for certain formulations. Because the acreage fallowed was highly correlated with time, it was not possible to detect the influence of fallow in several of the equations.

For Finney County, moisture variables more completely explained resource commitment and productivity then they did in Barton County, although the effects for precipitation were clear for this county also. Moisture was a more crucial factor in Finney County, where average precipitation was considerably less.

The influence of price, although less decisive than the effects of moisture, was detected for some formulations of the wheat seeding and fallowing equations for Barton County, and for Finney County for the acreage of all sorghums and grain sorghum harvested. It was also found that price influenced the acreage of wheat harvested and abandoned in both counties.

There was evidence that continuous wheat, wheat after fallow, and sorghums were competing crops. The acreage of sorghum harvested was clearly a function of acres of wheat seeded and acres of wheat abandoned. Likewise, acreage of wheat seeded was related to the acreage of cropland (growing row crops excluded). Because of this interrelation, a study of either could be made only if an integrated study was formulated, where the influence of the production of each on the production of the other could be ascertained.

The influence of the variable time was apparent in many formulations. This was true even after a correction had been made for the influence of other variables.

For most of the wheat production and wheat yield formulations, the dependent variable was associated with soil moisture as reflected by precipitation for prior periods. However, for the wheat seeding equation, no evidence was detected that farmers change their wheat acreage seeded in response to these precipitation variables. Thus, there is some indication that farmers may not be exercising as much strategy in the use of soil moisture as would be profitable.